WHOI-2009-01

Woods Hole Oceanographic Institution

The N456 Navigator System

by

Lane J. Abrams

Woods Hole Oceanographic Institution,
Woods Hole, Massachusetts

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Technical Report

Funding was provided by the National Science Foundation
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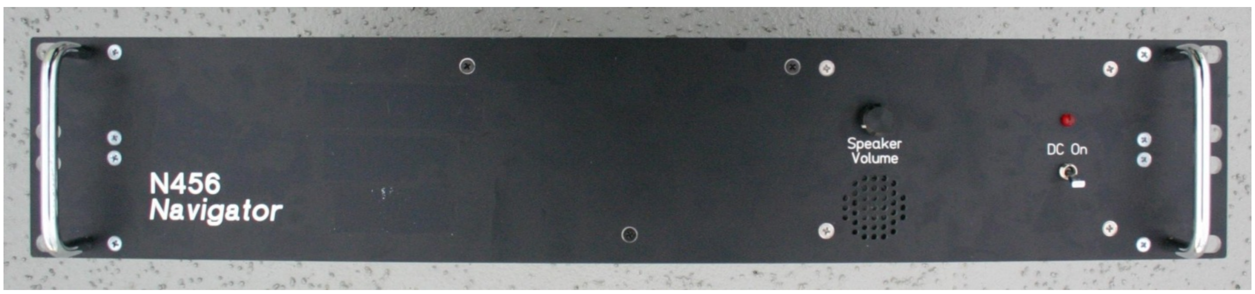
Approved for Distribution:

James F. Lynch, Chair
Department of Applied Ocean Physics and Engineering

Background

The *N456 Navigator* has been developed to assist in Long Baseline (LBL) acoustic navigation. Its two basic functions are generation of acoustic signals, and receipt and timing of returns. When combined with the new *dsnav* software, this becomes the basic component of an LBL navigation system. The principal motivation for this development was as a replacement for the Benthos 455 Acoustic Signal Processor[1] and the Alvin's NavBox[2]. The *N456* is intended for use in the Jason Control Van, in the Alvin submersible, and in the Atlantis TopLab. Enough flexibility is built into this system to be able to interface with a wide variety of ceramic transducers, or with an EDO 5400 Underwater Telephone.



N456 Front Panel View

Through the hardware and software of the system a series of pings is generated, which are used to interrogate underwater vehicles, instruments or transponder nets. In general, pings are about 15mS in length, and vary in frequency from 7.0 kHz to 16.0 kHz in 500 Hz steps. The output waveforms are programmable. This document describes those currently loaded into the version G firmware.

When pings are generated, equipment in the water (transponders or vehicles) hear them and may respond with pings of their own. The basic LBL function is based on timing the receipt of these responses, calculating the distance the transponders or vehicles (by knowing the speed of sound), and calculating the best-fit location. To facilitate this function, a timer is started when the interrogation ping is produced, and the measured time is reported whenever a response is heard. A more complete description

[1] *Benthos Model 455 Acoustic Signal Processor Technical Manual*. Benthos, Inc., North Falmouth, MA. 1986.

[2] Waters B. "Alvin Navigation Box A320201B," unpublished. May 1998.

of LBL operations can be found[3]. Responses can be selected in frequency from 7.0 kHz to 15.0 kHz in 500 Hz steps; the time of each response from each selected frequency can be reported. Input waveforms are programmable, and this document describes those loaded in the version G firmware.

In some circumstances, it is desirable to issue an interrogation ping without starting or resetting the timer, and the system can support this. Additionally, one of the output waveforms is a Dummy Ping, which has the same behavior as an interrogation ping but puts no sound into the water.

The *N456* equipment can also produce arbitrary command signals. The *dsnav* code currently supports Benthos release codes A through G, with provisions to produce additional release codes as well. Where most of the pings involved in LBL navigation are relatively short pings, these command signals can be extended in time, lasting several seconds. Though anticipated, this feature is not fully operational at this time.

Much credit goes to Tom Austin for design, development and continued support of the Digital Transponder Board, marketed through Hydroid. Credit also goes to Jonathan Howland, for development of the *dsnav* control software. Much of the magnetic design and testing was by John Bailey. Principal integration testing occurred during Atlantis/Alvin cruise #AT15-39, Craig Cary chief scientist.

LBL Modes Supported

There are a variety of LBL navigation modes supported with this equipment. Each of these provides some combination of navigation visibility for the surface ship and underwater vehicle(s).

1. Vehicle Navigation
   In this mode the vehicle or surface ship interrogates the transponder net, times the responses and calculates its own location. This is most often used to navigate the Alvin in cases where the Atlantis cannot reliably hear the returns from transponders. The submarine can calculate its own location but the ship cannot.

[3] Hunt MM, Marquet WM, Moller DA, Peal KR, Smith WK, Spindel RC. 1974. An Acoustic Navigation System. Woods Hole (MA): Woods Hole Oceanographic Institution. Technical Report No. WHOI-74-6.

2. Relay Navigation
   In this mode, the surface ship interrogates the vehicle, which then acts as a transponder to interrogate the transponder net. Returns are timed by the surface ship to determine the vehicle's location.
   If the vehicle can also time the responses, it can determine its own location as well. In the N456 system, this is accomplished by the vehicle issuing a dummy ping a short period before the expected time of the ship's interrogation ping. When the ship's interrogation arrives at the vehicle its time can be noted, and subsequent transponder response times noted as well. By subtraction, the travel times from vehicle to the transponders, and therefore the vehicle location, can be calculated.
   This mode is often used to navigate the Alvin in cases where time synchronization between ship and submarine is not satisfactory. Both the ship and the submarine can calculate the submarine's location.

3. Synchronous Navigation
   If both the surface ship and vehicle have accurate enough clocks, they can operate synchronously. In this mode, the vehicle interrogates the transponder net, times the responses and calculates its own location. In addition to this, the presence of accurate clocks allows the surface ship to produce a dummy ping at the same moment as the vehicle's interrogation ping. This operation lets the surface ship time the signals from the vehicle and the transponders in order to calculate the vehicle's location.
   This is the preferred navigation mode for the Alvin. Ship and submarine must be properly synchronized, the submarine controlling the interrogations. Both ship and submarine can calculate the submarine's location.

4. Tracking
   The Alvin provides frequent tracking pings for use by the Nautronix USBL receiver. While not strictly a navigation mode, this is a function which can be provided at the submarine in conjunction with the other navigation modes. These pings are produced every few seconds to provide an azimuth and depression angle to the submarine. When combined with the submarine's known depth, its location can be calculated.
   When used in conjunction with other LBL functions, care must be taken to prevent the USBL pings from interfering with the LBL pings, by selecting the USBL frequency as one which neither the transponders nor vehicle are using. Also, since these pings are not involved in the LBL system, the *N456* timing functions are not used or affected.

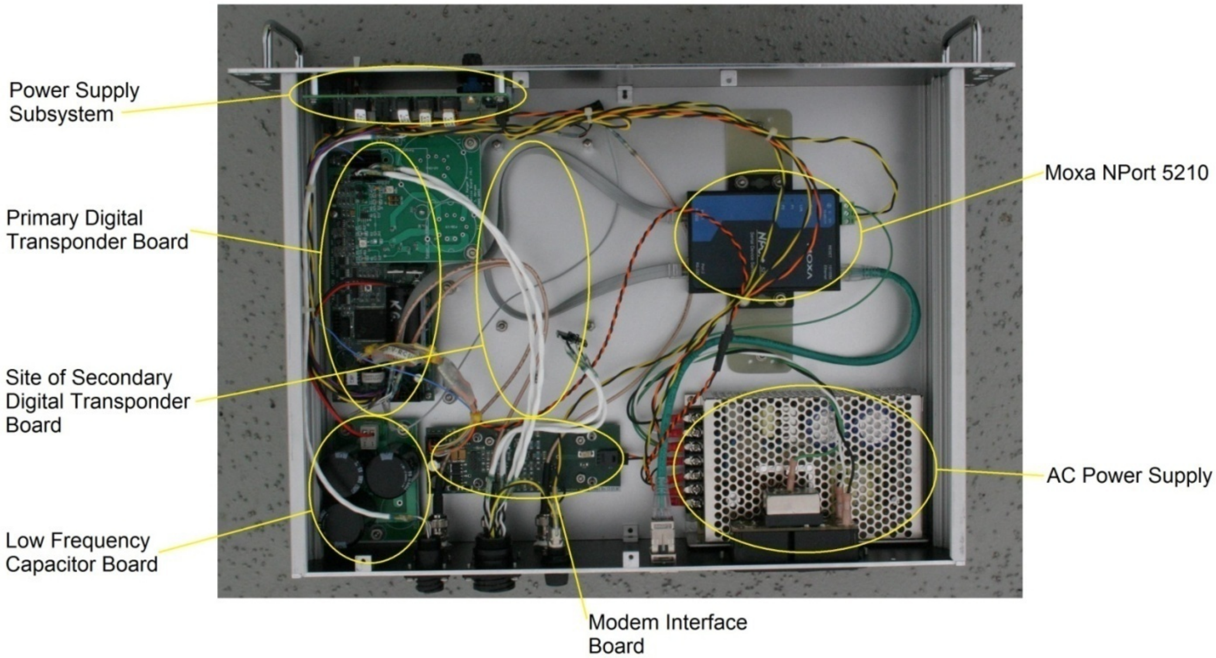
5. PRV Mode
   This is a common navigation method for the Jason/Medea system. In this mode, a trigger is sent down the tether, where it is causes an interrogation pulse from Medea. Boards dedicated to Medea and Jason both time the transponder responses to enable calculation of their respective vehicle positions.

Description

The *N456 Navigator* is a 2U rack mount assembly that contains the hardware required to perform acoustic navigation functions. With an overall size of 16.5” W x 3.3” H x 12.2” D (though the front panel is 19” wide), the internal components include:

1. Hydroid Digital Transponder Board
2. Moxa NPort 5210
3. Magnetics Interface Board
4. Low-Frequency Capacitor Board
5. Hydroid Modem Interface Board
6. Power Supply Subsystem

General specifications are included in Appendix A. The principal schematics for the *N456* and its WHOI-built components are included in Appendix C.



N456 Internal Components

N456 Back Panel Connectors

The back panel **I/O** connector is used to provide DC input power, as well as line-in and line-out signals from both Digital Transponder Boards (if so installed). It is an AMP 206036-1, 16-pin bulkhead CPC connector. It's mating connector is AMP 206037-1 with pinout:

Pin #	Function
1	24Vdc Power Return
2	24Vdc Power Input
3	
4	Board 1 Line Out Shield
5	Board 1 Line Out Return
6	Board 1 Line Out
7	
8	Board 1 Line In Shield
9	Board 1 Line In Return
10	Board 1 Line In
11	Board 2 Line Out Return
12	Board 2 Line Out
13	Board 2 Line Out Shield
14	Board 2 Line In Shield
15	Board 2 Line In Return
16	Board 2 Line In

The back panel **Transducer** connector is used to connect the Digital Transponder Board #1 to a ceramic transducer. It is an AMP 206061-1, 4-pin bulkhead CPC connector. It's mating connector is AMP 206060-1 with pinout:

Pin #	Function
1	Transducer Cable Shield
2	Transducer Return
3	
4	Transducer I/O Signal

BNC connector **1PPS In** is used to supply a 1 Pulse-per-Second signal into the *N456*, going to the Din_4 trigger input of Digital Transponder Board #1. This signal is required for the synchronous operating modes, where outgoing pulses are synchronized to this signal. This TTL signal must be active rising-edge, with the high level at least 100µSec in duration. With this signal provided, pings issued synchronously are not made immediately, but rather upon receipt of the 1PPS signal.

BNC connectors **Trig #1 Out** and **Trig #2 Out** are used to transmit timing signals produced by the Digital Transponder Board(s). When an outgoing ping is produced, an open-collector, active low signal can also be produced which appears on these connectors. Whenever a signal is produced on **Trig #1 Out**, it is also sent to the Din_5 trigger input of Board #2.

The **LAN** connector is an RJ-45 jack to provide an Ethernet connection to the *N456 Navigator*.

Description of the Digital Transponder Board

All of the acoustic functions are performed by Hydroid's Digital Transponder Boards, which provide synthesis of pings and timing of returns. This is a serially controlled device, accepting and processing commands from the *dsnav* software. One of these boards is required for system operation. A second must be installed to support PRV mode.

A copy of the complete command description of the Digital Transponder Board[4] Is included in Appendix B.

The Magnetics Interface Board

The Digital Transponder Board is designed to be configured for a specific transducer, by installing the proper inductor and transformer. To enhance flexibility of the system, the *N456* does not require these components to be soldered directly onto the board, but rather onto a separate Magnetics Interface Board. In this way, a variety of Interface Boards can be kept on hand and changed relatively easily, without having to unsolder the magnetic components from the Digital Transponder Board. Alternatively, circuitry can be installed on the board to provide line-level output from and input to the Digital

[4] Austin T, Digital Transponder Serial Interface Protocol for DSL console, Rev B 3-30-08.

Transponder Board, for example to drive an Underwater Telephone system. The magnetic circuitry and the line-level circuitry should not be installed at the same time.

When using the Line-in/Line-out signals, note that the return level of the two signals is not at the same potential. So it is important to be sure that the two returns never come into electrical contact with each other, either through inadvertent shorting or in the driven equipment. Should this occur, it is likely that the driver components Q1 and/or Q2 of the Magnetics Board will be damaged. For example, in the Alvin's Underwater Telephone, both input and output signals are transformer coupled, so this does not pose a problem.

To interface directly to a transducer, the Magnetics Interface Board must be populated with an appropriate transformer T1 and inductor L1 to match the Digital Transponder output signal to the transducer. While not intended to be a complete design guide, the essential steps are:

- The Digital Transponder Board's output signal is a square wave of approximately 22Vp-p, at the frequency of the ping.

- The signal amplitude to the transducer must be identified. For instance, for a Benthos SP23-LT transducer, an input signal of 800Vp-p will yield a ping of satisfactory intensity.

- The transformer rule of $V_{out} = n^2 * V_{in}$ is used to calculate the required turns ratio. In the case of an SP23-LT, a turns ratio of 6 is appropriate.

- The inductor value is selected to compensate for the transducer's impedance, so that the series combination of the inductor and the (capacitive) transducer has as little reactive part as practical. An SP23-LT's impedance is close to resistive at frequencies near 10 kHz, so no inductor is required. A jumper is used instead.

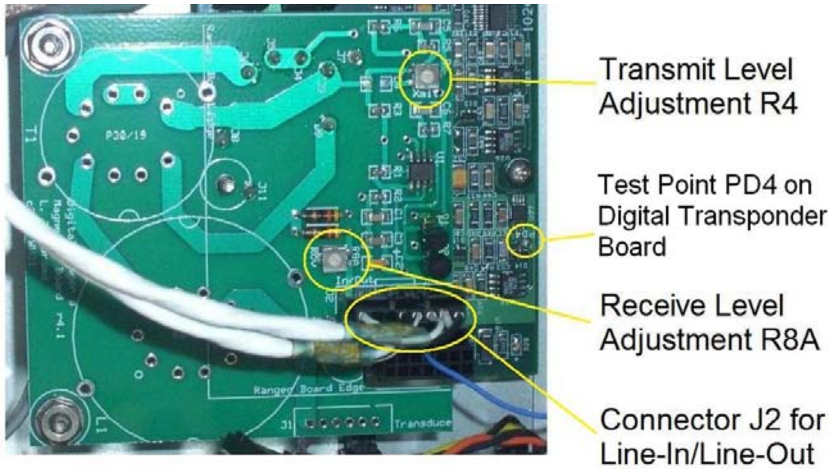
- The Magnetics Board is designed to use Ferroxcube size P30/19 components for the transformer T1 and Ferroxcube P42/24 components for the inductor L1. Recommended core materials are 3B7-A1000 for the transformer and 3C85-E160 for the inductor. From the characteristics of these materials, the number of turns must then be calculated. For the SP23-LT, a transformer of 20:120 turns has performed well.

Magnetics Interface Board, populated for SP23-LT Transducer Interface

To interface to the Line-In/Line-Out signals, the electronic components of the Magnetics Interface Board must be installed instead of the transformer and inductor. These components buffer the transmitted signal to about ±10V, and send the received signal directly to the Digital Transponder Board's receiver. Both the transmitter and receiver have a signal level adjustment. The transmitter should be adjusted to provide maximum signal without distortion. The receiver should be adjusted to provide maximum signal with minimum noise.

To adjust the transmitter, it is best to monitor the signal with a "T" on the line between *N456* and the driven equipment. By commanding the *N456* to ping frequently (once per second is very easy to control with the *dsnav* software), the adjustment can be made on potentiometer R4 while watching the signal waveform on an oscilloscope.

To adjust the receiver, test point PD4 on the Digital Transponder Board is used, with the black wire of the Board's large capacitor as return. This point is mid-way through the receiver's amplification stages. While signals are being received, monitor this test point on an oscilloscope and adjust the receive gain on potentiometer R8A until the receive signal is just clipped, at about 3Vp-p. Ideally, the noise level will be below 50mVp-p as well. If the noise is greater than that, the receive gain should be set as a best compromise between signal level and noise level.



Magnetics Interface Board, populated for Line-On/Line-Out Signals

When removing or installing the Magnetics Interface Board, be very careful to not bend or damage the interconnecting pins. To remove the Board, slowly pull straight up until the pins disengage. To install, fit the board onto the mounting screws first to help line up the pins, then gently and evenly push it in place.

The Low-Frequency Capacitor Board

The Digital Transponder Board was originally designed to operate with signals at a higher frequency than those used for LBL with Alvin and Jason. While there is enough energy storage on-board to supply power for higher frequency signals, there is not enough for the lower frequencies. This board contains extra capacitance to store the energy needed to power these signals.

Modem Interface Board

Though the Capacitor Board can store enough energy to power the low frequency pings needed by the *N456*, there is still not enough to produce a complete release code. To do this, one of Hydroid's Modem Interface Boards is installed to augment the power available for the signal.

Power Supply Subsystem

Power for the *N456 Navigator* can be provided as either 120Vac or 24Vdc. AC power is supplied through a standard IEC power cord, with a switch and fuse on the back panel.

This runs to an internal power supply to make 100W of 24Vdc. DC power (24V nominal) is provided in the I/O connector, with a fuse on the back panel.

Whichever power source is used, DC power to the internal electronics is controlled with a front panel switch and includes internal power filtering. An indicator light shows DC power status.

The Power Supply Subsystem also includes an audio speaker controlled by a front panel volume knob to hear the received acoustic signals.

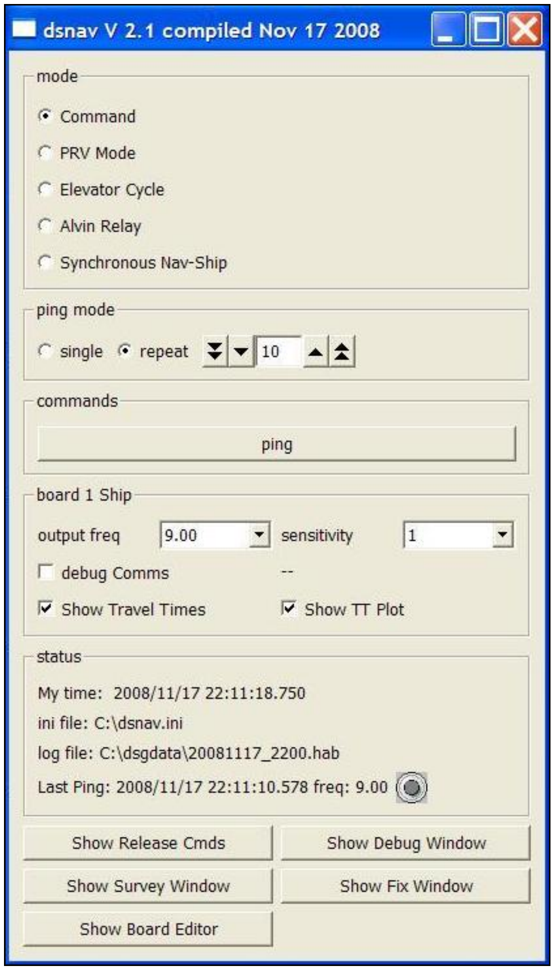
Using the ***dsnav*** Software

The *dsnav* software controls all of the activities of the *N456* system, and provides the user interface to those activities. A GUI operator window is used to select the principal operating mode of the system, and provide controls to adjust those operations. Various reporting and diagnostic displays are also shown or can be selected. Complete log data is recorded and data output is through UDP via $PWHTT string to the *DVLNav* program.

Great variety and flexibility is built into the *dsnav* software. Complete details are separately documented.

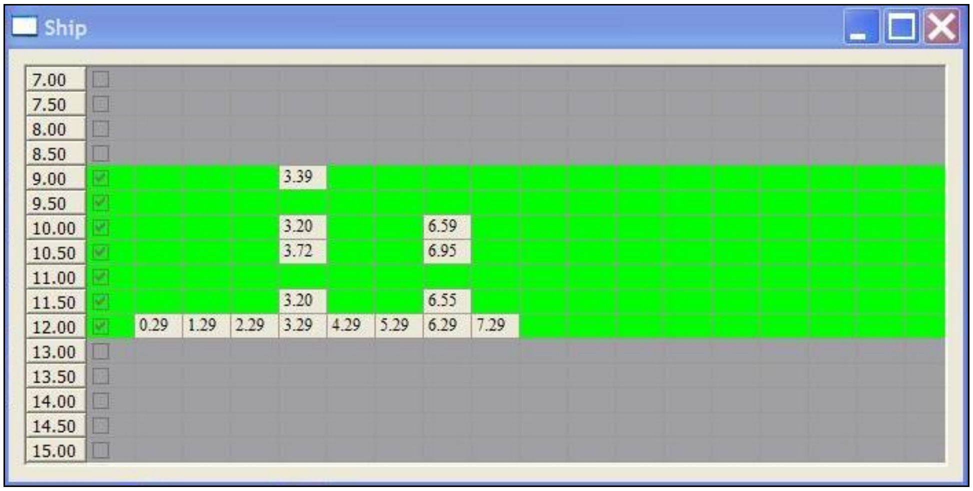
The principal operating modes available to the user are described in the *dsnav.ini* file and selected on the top portion of the Main GUI screen. These include modes to ping at a particular frequency and repetition rate, or to produce a specific sequence of pings each minute. A more specific description of the Alvin operating modes as of the date of this document is included in Appendix D. A copy of the current *dsnav.ini* file defining these modes is included in Appendix E.

The center portion of the Main GUI screen provides controls specific to each Digital Transponder Board installed, such as communication status, receive signal sensitivity and transponding functions.



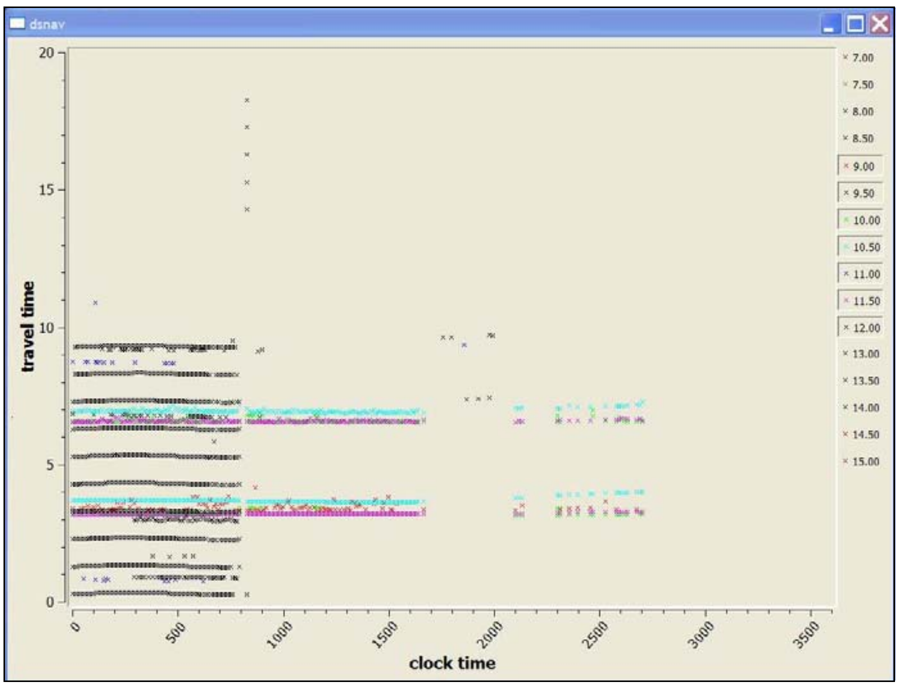
dsnav Main GUI Screen

For each ping, the Travel Time display shows the travel times of each acoustic return received by the *N456*. When the new ping is made, the display clears and shows the travel times for this ping. Travel Times are only received by those frequency channels which are selected, and can be further filtered on the Board Editor by minimum travel time, maximum travel time, and interval between returns. The Travel Time display can be enabled or disabled with a check-box on the Main GUI.



N456 Travel Time Display

The Travel Time History Plot shows the history of travel times received, plotting them for each frequency channel being received and displayed. The Travel Time History Plot can be enabled or disabled with a check-box on the Main GUI.



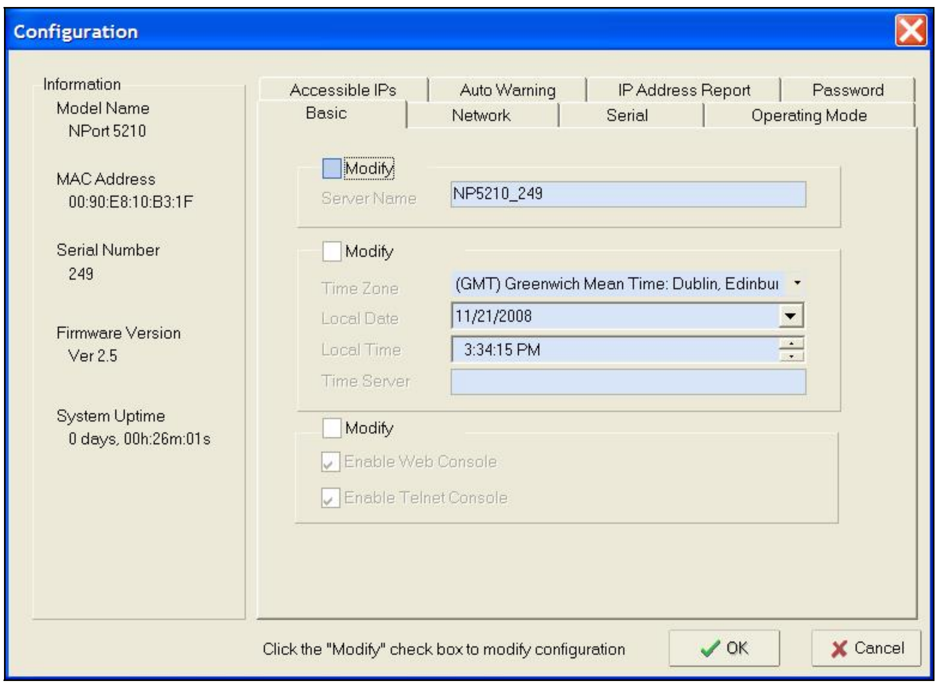
Travel Time History Plot

Configuration of the NPort 5210

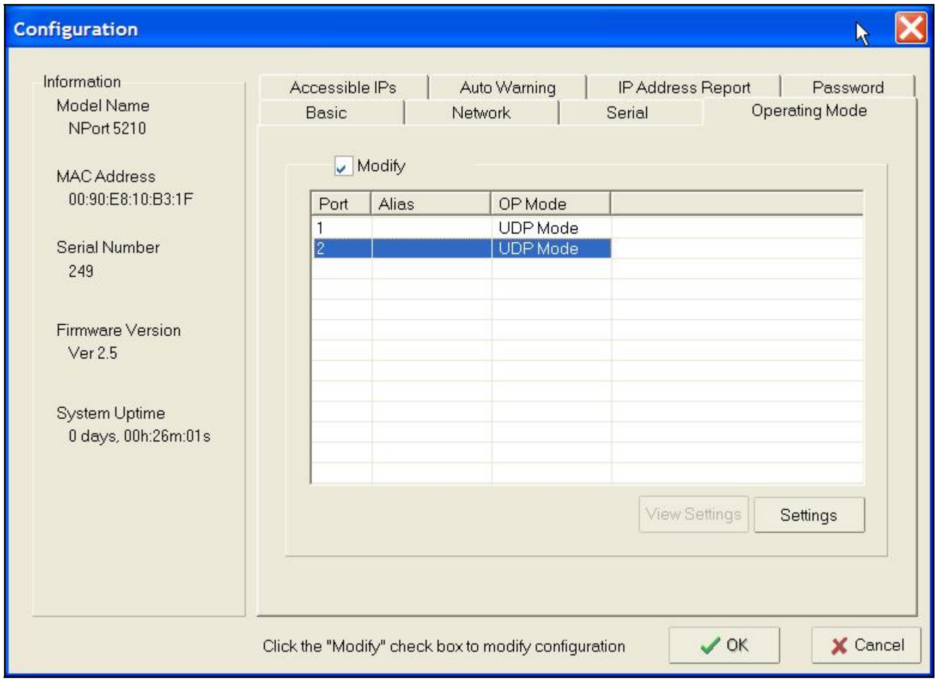
The *dsnav* software communicates with the Digital Transponder Board(s) via Ethernet through a Moxa NPort 5210. This device interfaces the Ethernet-based UDP transactions used by *dsnav* into RS232 signals used by the Digital Transponder Board.

The NPort 5210 must be properly configured by using Moxa's *NPort Administrator* tool. With this tool, the NPort's IP number is assigned, and its two ports are configured for UDP control and RS232 characteristics 115200 baud, No parity, 8 data bits, 1 stop bit. Complete details of the *NPort Administrator* tool can be found in the Moxa documentation or Web site.

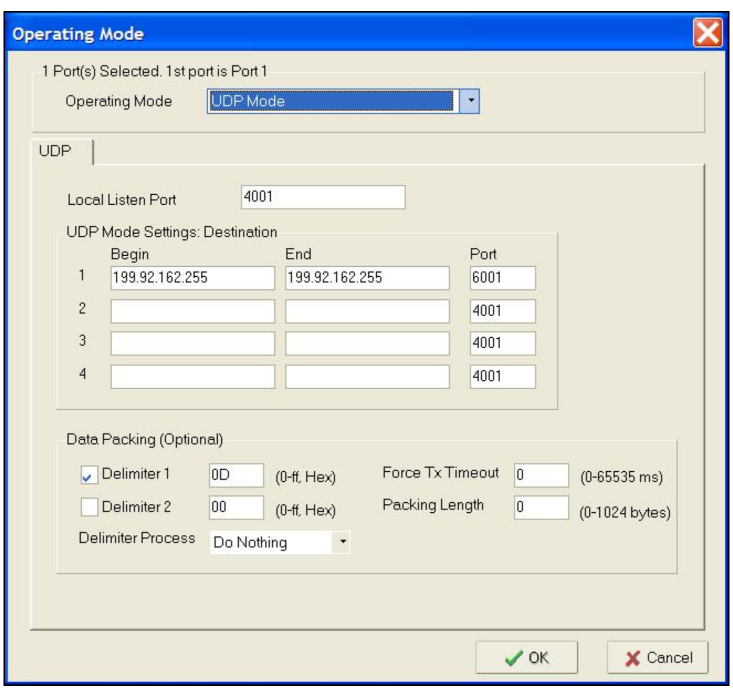
On starting the NPort Administrator, the proper NPort must first be selected. This is done by searching for the proper device, by Model Number and/or IP number. Once selected, information about the device is displayed:



In the **Operating Mode** tab, select **Port 1**, make sure **Modify** is selected and click **Settings:**

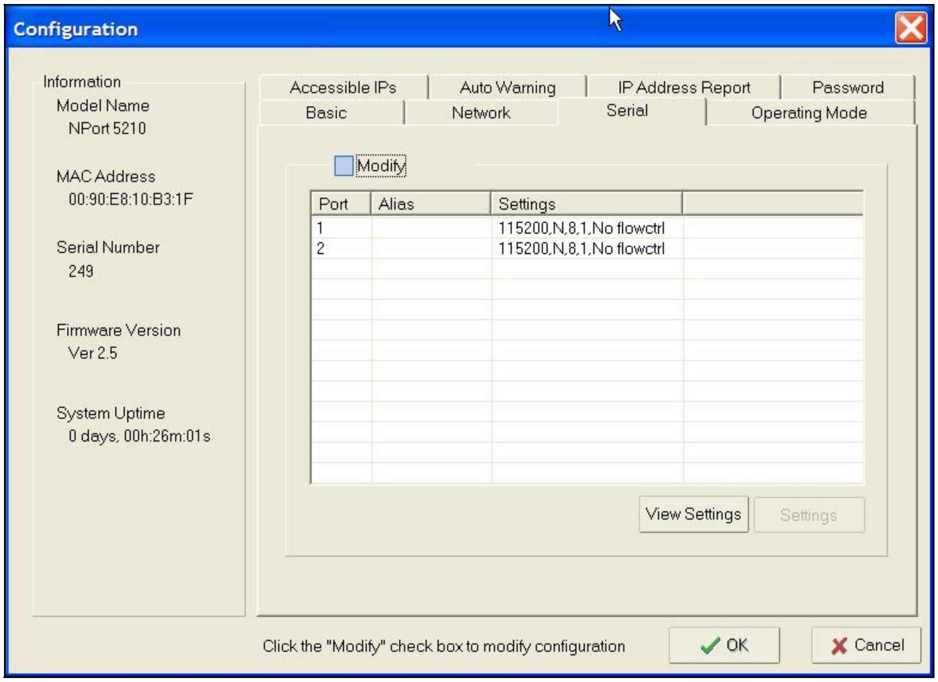


to adjust the port parameters to operate in **UDP Mode**, transmit data to the proper IP number for the *dsnav* program's computer, receive on UDP port 4001, transmit to UDP port 6001, and select the **Delimiter 1** value to **0D** (a zero, not the letter O, and the letter D):

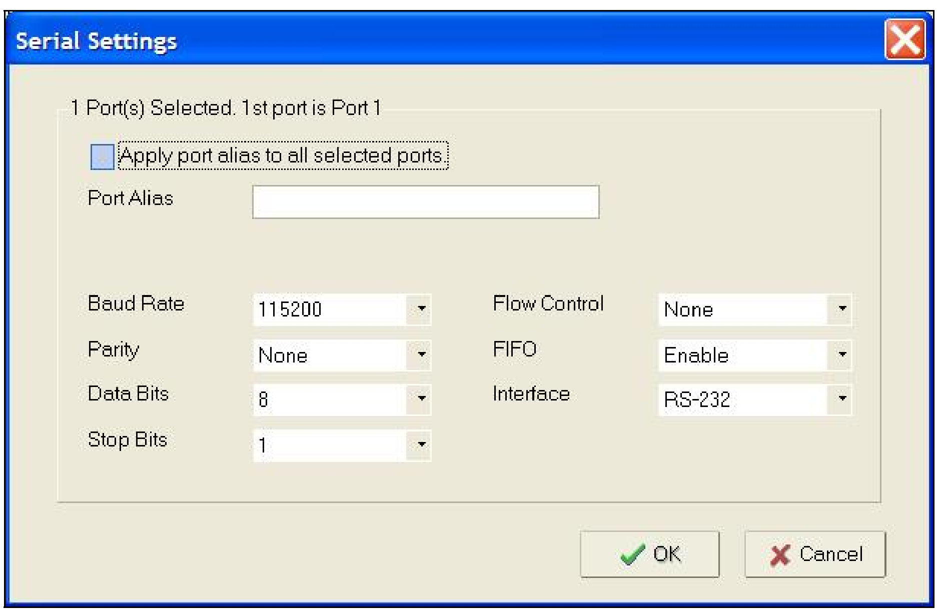


UDP **Port 2** is configured in the same way, but to listen on UDP port 4002 and transmit on UDP port 6002.

In the **Serial** tab, select **Port 1**, make sure **Modify** is selected and click **Settings:**



to adjust the port to **115200** Baud, **None** Parity, **8** Data Bits, **1** Stop Bit, **None** Flow Control:



Serial **Port 2** is configured in the same way.

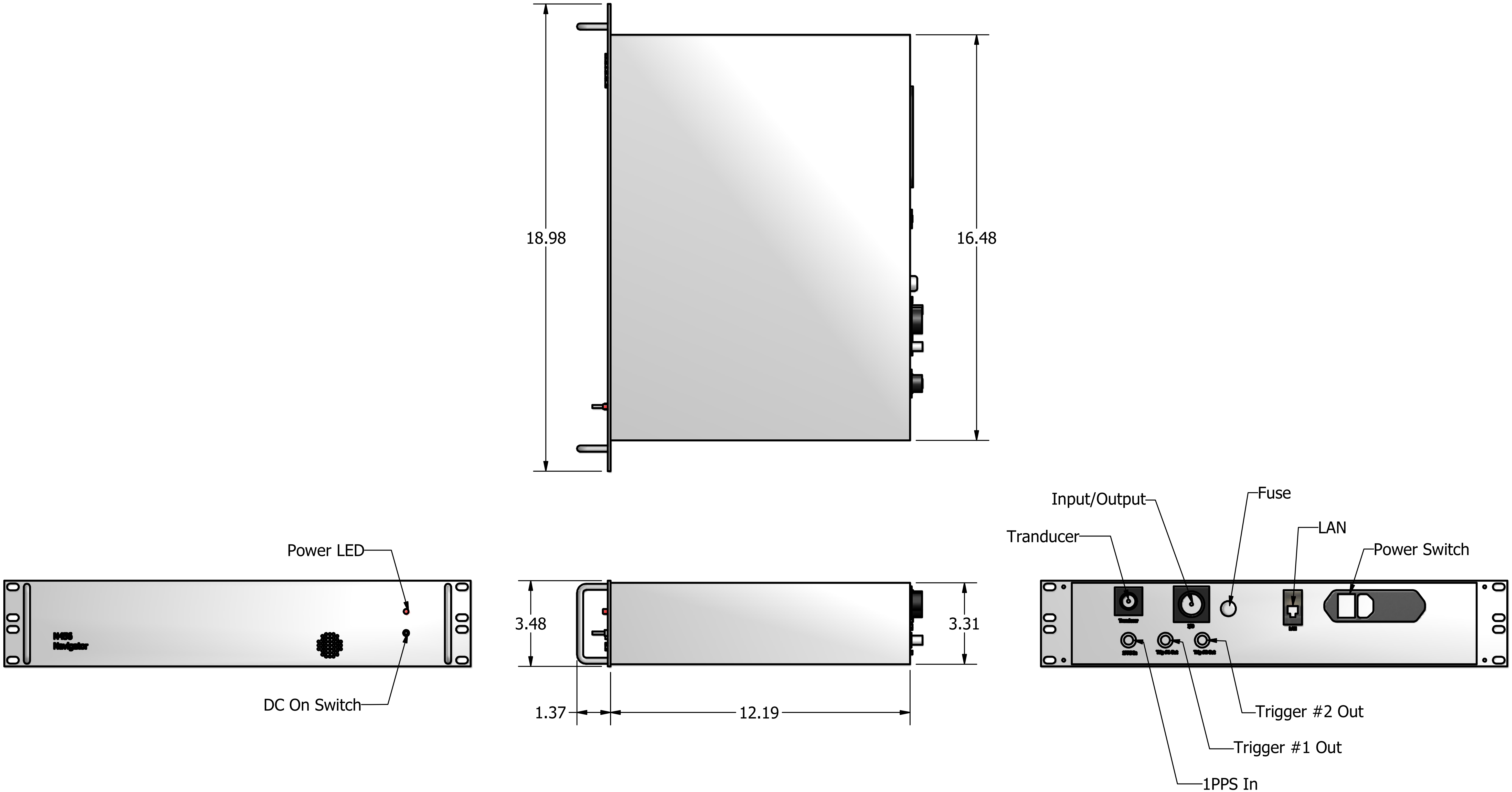
Installation of the *dsnav* Software

A number of DLL's must be carried along with the *dsnav.exe* executable. These should be placed in the same Windows folder as the executable. The *dsnav.ini* initialization file is located by default in the C:\ folder.

Appendix A

N456 Navigator General Specifications

Dimensions	$16^{1}/_{2}$" (w) x $3^{5}/_{16}$" (t) x $12^{1}/_{4}$"(d) Excluding 19" wide front panel and rear panel connectors
Weight	11 lbs
Power	100 – 264Vac, 47 – 63 Hz or 18 – 26Vdc 10W while receiving Up to 150W while transmitting
Environment	0° – +40°C ambient temperature 20-90% RH non-condensing


18.98
16.48
Power LED
DC On Switch
3.48
3.31
1.37
12.19
Tranducer
Input/Output
Fuse
LAN
Power Switch
Trigger #2 Out
Trigger #1 Out
1PPS In

Digital Transponder Serial Interface Protocol for DSL console

Rev. B, 3-30-08

LBL Ranging Transmit: A serial message would instruct the transponder board to transmit a ping of waveform "ww" (where ww = 0-FF). A flag in the message will tell it whether to wait for the next sync pulse, or whether to just go ahead and send it. If the sync mode is selected, it will go ahead and transmit after a timeout in the event that no sync pulse occurred. Un-synchronized transmissions are synced to the leading edge of the start bit of the first character of the "ping" message, for Paradigm compatibility.

> **#Dn,P,ww[,s,t](CR)**,
> where n=board address, ww=transmit signal (bits 00-ff, up to maximum number of signals, error if higher), s=sync control (0-F), and t=sync timeout (1-F=100-1600 ms)
> Note: sync control includes the bit mask for inputs Din_4 – Din_5. Din_5 is active low, and Din_4 is active high. Check system wiring diagram to determine which input or inputs is to be used. Minimum pulse length is 100 us.
> The upper bit of sync mask will enable a tx_sync output, open collector, active low, for the duration of the transmit ping on Dout_3. Bit 2 may be set to disable the clearing of the receive clock.
>
> **Sync control bit descriptions:**
>
> Bit 0: if 1, external sync is enabled on DIN_4, active high. Note: Bit 1 should be 0.
> Bit 1: if 1, external sync is enabled on DIN_5, active low. Note: Bit 0 should be 0.
> Bit 2: if 1, receive clock is not reset on transmit.
> Bit 3: if 1, tx sync output is generated. Tx sync out is active low, duration is same as tx signal pulse length.
>
> Reply: **!Pn(CR)**

Status Request: A serial message would request the transponder board's status. The status reply would indicate the code of the most recent command reception, since the last request (0-24, 0 means none), and four flag bits indicating whether replies have arrived on any of the four receive channels. A reply detected on channel 1 could be used to reset the REMUS keep-alive timer. A separate message requests the battery voltage.

> **#Dn,S(CR)**, where n=board address.
> Reply: **!Sn,[ss,]rr,cc(CR)**, where rr = reply flags(00-FF, with each bit corresponding to a receive channel), cc = command code received(0-24, 0=none), both cleared after this request. Note: bit 7 of "cc" is set if a power up or watchdog reset has occurred. All flags are cleared after the reply has been sent.
> On 16 channel unit only: ss=reply flags for channels 9-16.
>
> **#Dn,B(CR)**, to request battery voltage (ranger/buoy configuration only)
> Reply: **!Bn,bb(CR)**, where bb=battery voltage(00-FF=0 to full).

Travel Time Request: A serial message would request the travel time on channel "m", where "m" is an input parameter. Normally, this would be requested after a detection on that channel was noticed in a status request. The requested travel time is cleared to zero after this message has been sent. All travel times are cleared to zero following the ping command.

> **#Dn,T,m(CR)**, where n=board address, and m=channel number (1-F for channels 1-15, 0 = channel 16).
> Reply: **!Tn,m,rrrrr,ii,oo(CR)**, where rrrr is the travel time in hex, 12.8 micro-seconds/count, and ii is the in-band signal to noise ratio (00-FF), and oo is the out –band signal to noise ratio (00-FF). Out-band is a relative measure of the ambient noise out of the matched filter just before the ping, and In-band is a relative measure of the peak amplitude of the matched filter output during the received ping.
>
> Note: The travel time counter is free running, and is only reset by the ping command. Therefore, multiple receptions may be received, or synchronous or hyperbolic navigation may be utilized.

Digital I/O: A serial message may set the digital output bits DOUT_0 – DOUT_2. It will also read back the digital inputs DIN_2 – DIN_7.

> **#D1,O,x(CR)**, where x=digital output, 0-7 hex to set digital output bits or "?".
>
> > DOUT_0: set to 0 if bit 0 of x is 1.
> > DOUT_1: set to 0 if bit 1 of x is 1.
> > DOUT_2: set to 0 if bit 2 of x is 1.
> > Note: outputs are open drain, external pull-up resistor is required to 5 Volts or less.
> >
> > If x= "?" then no change to digital outputs.
>
> Reply: **!O1,ii(CR)**, where ii = digital input bits DIN_2 – DIN_7.
>
> > Bit 0 – 1 of ii: always 0
> > Bit 2 – 7 of ii: DIN_2 – DIN_7, respectively.

Transpond Feature: Channels 1 and 2may be used as transpond channels. This serial command is used to specify the reply waveform number for each channel. Waveform number 00 will disable transpond. Turnaround delay is fixed at 50 ms, and the receiver lockout is fixed at 3 seconds for channels 1 and two at all times, regardless of whether transpond is enabled or not. Therefore, these two channels may not be useful for bounce path navigation in normal mode.

#D1,R,n,ww(CR), where n is the receive channel number (1 or 2) and ww is the reply waveform number, from the transmit waveform table.

Threshold Adjustment: This command may be used to adjust the threshold, or sensitivity, of the receiver channels. This is a global setting and affects all channels. It provides approximately 8 dB of variation. It is a useful adjustment to reduce the false alarm rate, or to increase sensitivity.

#Dn,H,t(CR), where t=threshold setting, 0-F. 0 is most sensitive, and F is least sensitive. Default is 8 on power up.
Reply: **!Hn(CR)**

WHOI Command transmit: A serial message would request the transmission of a command of code "m". This would be used by the vehicle to release a deliverable transponder, or by the Ranger or Paradigm to send a command to the vehicle.

#Dn,C,mm,mm(CR), where n=board address, and mm=command code (00-FF) sent twice to eliminate any similarity with other messages, thus preventing an accidental transmit.
Reply: **!Cn(CR)**

Version Request: This serial message is sent to request the firmware version on the DSP transponder board.

#Dn,V(CR), where n=board address.

Reply: **!Vn,v,tttttttt(CR)**, where v=A,B,C…..Z, and ttttttt = 8 characters for the board type. Example:

#D1,V
!V1,A,DR3 (note: in this case there are 5 space characters following the "DR3".)

Arbitrary command signals (X-commands):

The 16 channel boards have a new capability that allows for transmission of any arbitrary command signal. The signal is loaded into memory prior to transmission using the serial interface. The commands for this function are as follows:

Load a new signal: This is accomplished by sending the signal text file. The text files include the length of the signal, sampling rates, and the signal itself, all arranged as a sequence of 16 bit words. A final message indicates that the end of signal has been reached, and passes a checksum for error checking. The file should be transmitted exactly intact with no additional characters or leaders. Normally there is no reply until after the final line has been sent. Any errors in the file or with the checksum will result in

a standard error reply message: **"!?1(CR)"**. If the file was accepted, the reply is: **"!X1(CR)".**
An example of a signal file is as follows:

```
#D1,X,L,00B6
#D1,X,L,004F
#D1,X,L,02AF
#D1,X,L,FFFF
#D1,X,L,FFF0
#D1,X,L,0000
.
.
.
.
#D1,X,L,FC00
#D1,X,L,0000
#D1,X,L,3FFF
#D1,X,L,FFFC
#D1,X,L,0000
#D1,X,L,007F
#D1,X,L,FFFF
#D1,X,L,F800
#D1,X,L,FFFF
#D1,X,L,C000
#D1,X,D,0ACA            ← Note that this is the final line,
                        ← one blank line is required at the end.
```

To send the X_command that was previously loaded:

#D1,X,S(CR)

Reply: **!X1(CR)** indicates the command is being sent.
!?1(CR) indicates that there is a problem with the signal, and the command could not be sent. The signal should be reloaded.

Note: The final line of the signal file serves to reset the pointer for the next load. If this command was not received, then it should be sent prior to starting a new load. This could be done prior to any load, just to be safe.

Note: Once a signal has been loaded, it will remain loaded until the board is rebooted, power cycled, or until another signal is loaded. However, since there is currently no way to read back the signal, to be safe, you should always load the signal prior to sending commands.

DSL Console frequency assignments for 16 channel configuration

Receive channels:

Channel number	TT request number	Frequency (kHz)
1	1	7.0
2	2	7.5
3	3	8.0
4	4	8.5
5	5	9.0
6	6	9.5
7	7	10.0
8	8	10.5
9	9	11.0
10	A	11.5
11	B	12.0
12	C	13.0
13	D	13.5
14	E	14.0
15	F	14.5
16	0	15.0

Transmit signals:

Waveform request number	Frequency (kHz)
01	7.0
02	7.5
03	8.0
04	8.5
05	9.0
06	9.5
07	10.0
08	10.5
09	11.0
0A	11.5
0B	12.0
0C	13.0
0D	13.5
0E	14.0
0F	14.5
10	15.0
11	16.0
12	Dummy

	click

Serial Bootload Procedure:

Users may update DSP firmware by loading a new program into the board using the serial port. This file is an ascii-hex file with a built-in serial bootload command at the beginning. Simply transfer this file to the board. The board will recognize the header message as a bootload command, and will automatically ingest all of the remaining data into RAM until it reaches the end of program memory. After that is reached, the board will automatically jump to the reset vector and will begin running the new program. To send the file:

- Start Hyper-terminal using the attached *.ht file. (2 Stop bits are required).
- Power up the board using the old code.
- Verify communication with the board by requesting version.
- Select "Transfer/Send Text file"
- Browse for the *.dat file that you wish to load.
- Select "Open"
- You will see the file scroll as it loads. Wait until the transfer is complete.
- There may be a few error replies (!n?) near the end of the transfer. This is normal as the files are often padded to be a little larger than the actual space allowed.
- Request the version again, and verify that it is now the new version.
- Test the operation and verify that the new code works correctly.
- Note that this program is not burned into EEPROM during this bootload process. Instead it is loaded into DSP RAM. This allows the operator the opportunity to try out the new code prior to making the commitment to write over the EEPROM. If you are happy with the performance, then you can commit it to EEPROM by sending the following command:

#Dn,F,B,Y(CR) , where n=board address

- There is no reply to this message. You must wait approximately 3 minutes for the burn to complete. Be sure power is maintained while this is underway. The LED on the board should blink briefly when complete, indicating that the board is rebooting with the new code.
- After three minutes, send a version request again and verify that the correct version is still running.
- Power cycle the board and check the version again.
- Update complete!

Appendix C

Schematic & Bill of Material

N456 Navigator

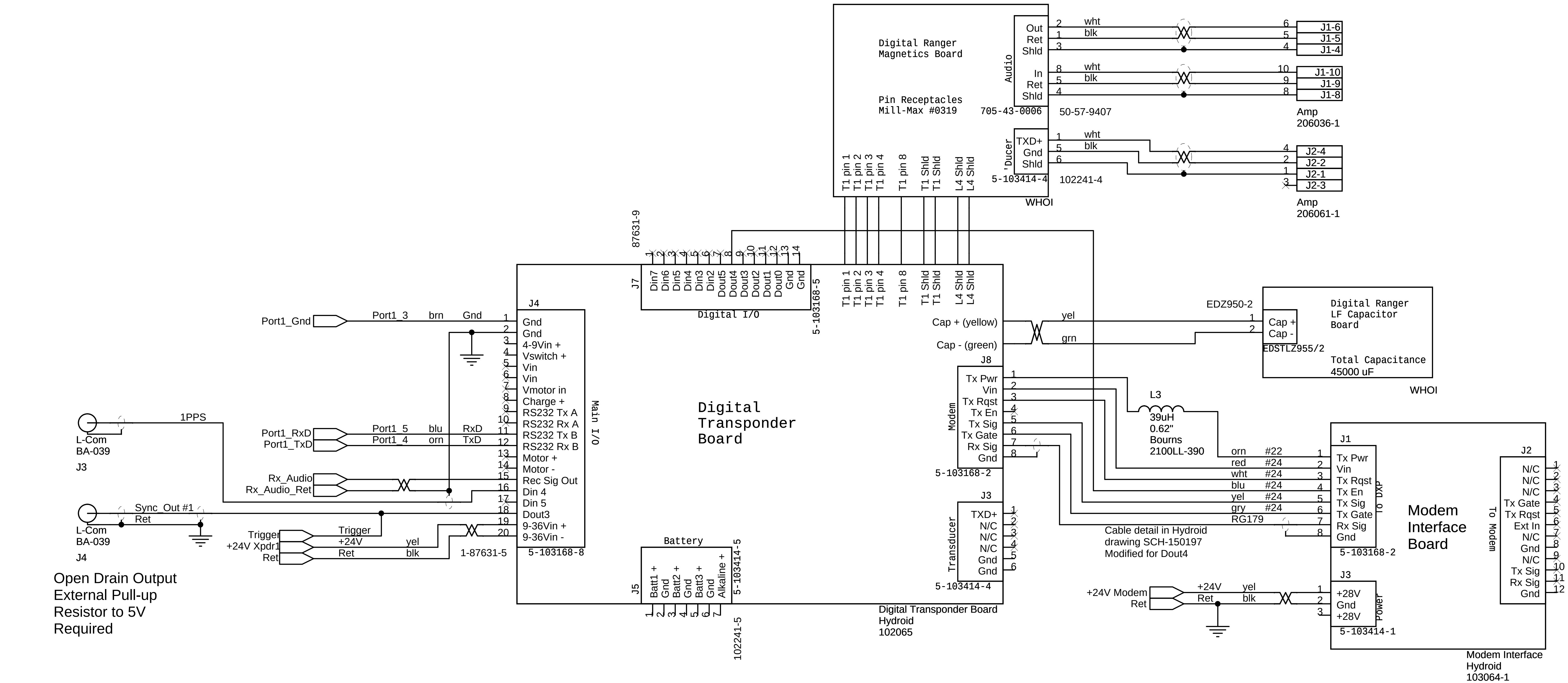
Magnetics Interface Board

LF Capacitor Board

Power Supply Board

Modem Interface Cable

REV	ECA #	REVISION	INIT & DATE	APVD
A		Modem Wiring Change	lja 28May2008	
B		Magnetics Board & Moxa Change	lja 25Jun2008	
C		Change Din_5 to Din_4	lja 2Dec2008	



The Digital Ranger is manufactured with no transformer, inductor or connector J3.

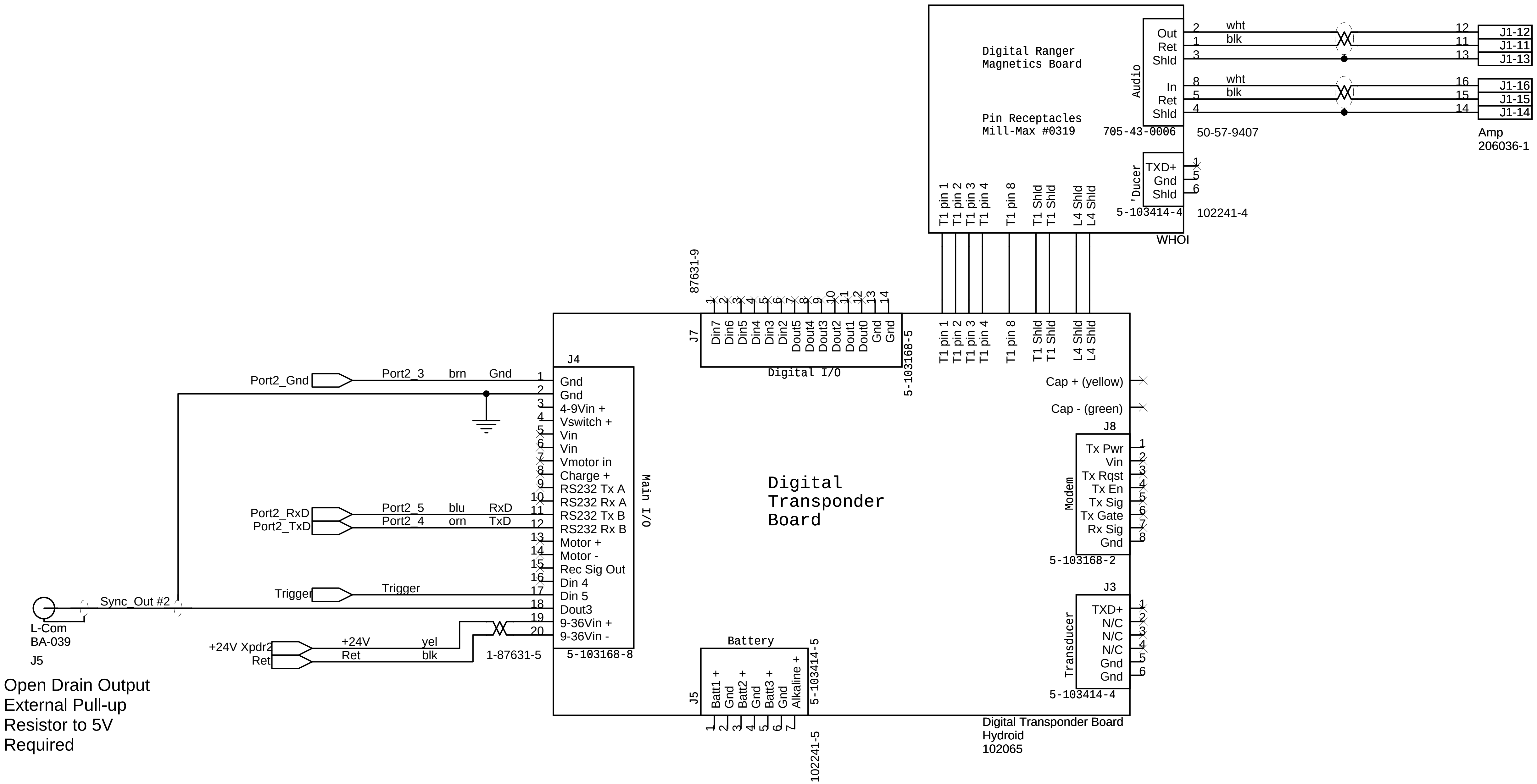
The Digital Ranger is provided with the -HF firmware option.

PC Pins Mill-Max #3102-2 and #3145-2 replace of these components.

PCB2 WHOI Capacitor Board 3.20"x2.15"

PCB3 WHOI Magnetics Board 3.20"x3.23"

Original Date: Wednesday, February 06, 2008	Woods Hole Oceanographic Institution Submersible Engineering & Operations Group
Draft: L. J. Abrams	N456 Navigation System Digital Transponder Board #1
Apvd <Checker>	
Sheet Size: B	
Scale: -	Dwg # - / Rev C / Sheet 1 of 4



Open Drain Output
External Pull-up
Resistor to 5V
Required

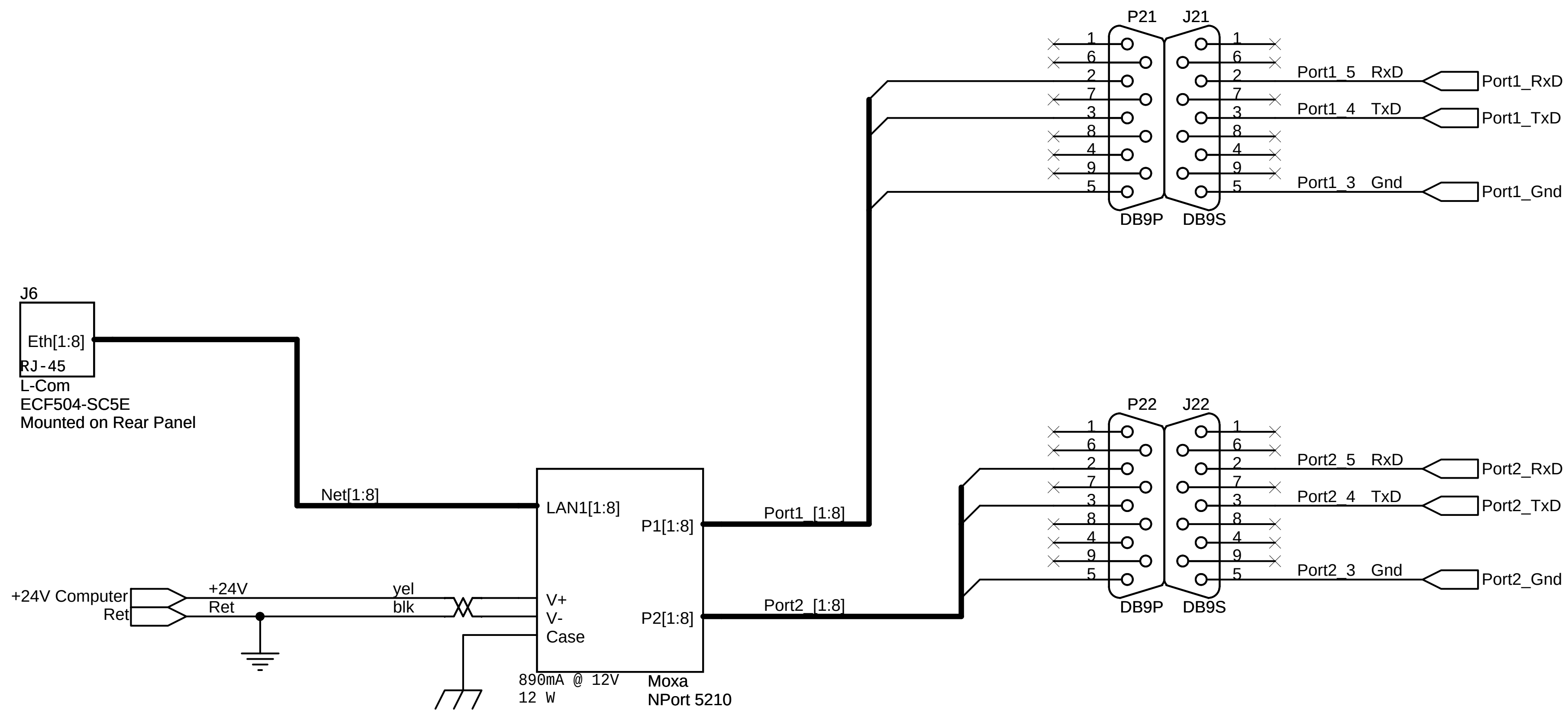
The Digital Ranger is manufactured with no transformer, inductor or connector J3.

The Digital Ranger is provided with the -HF firmware option.

PC Pins Mill-Max #3102-2 and #3145-2 replace of these components.

PCB4
WHOI
Magnetics Board
3.20"x3.23"

Original Date: Monday, March 24, 2008	Woods Hole Oceanographic Institution Submersible Engineering & Operations Group
Draft: L. J. Abrams	N456 Navigation System Digital Transponder Board #2
Apvd <Checker>	
Sheet Size: B	
Scale: -	*Dwg #* - *Rev* C Sheet 2 of 4



HW5
Cable for Serial Port
L-Com
TDC005-1

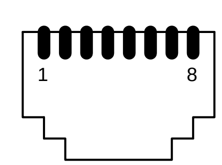
HW6
Cable for Serial Port
L-Com
TDC005-1

HW7
Cable for Ethernet
L-Com
TRD695GR-1

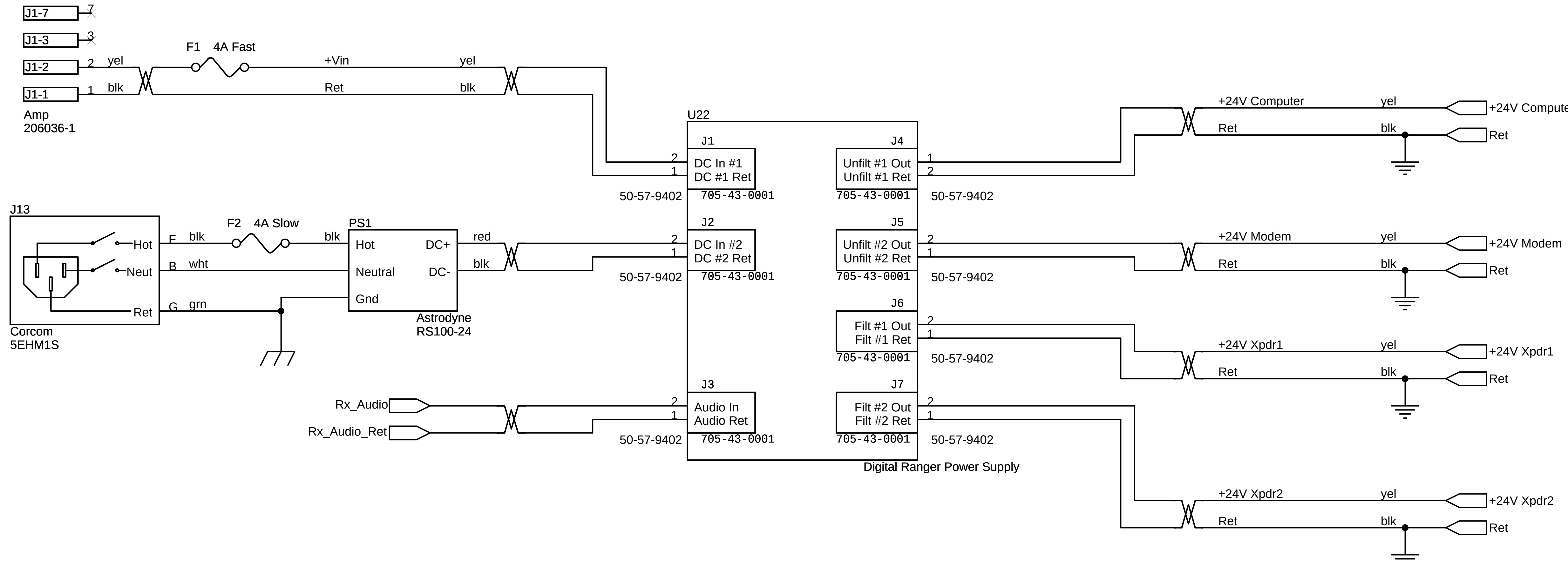
NPort 5210 Serial Ports

RJ45 Pins	RS232	DB9 Pins
1	DSR	6
2	RTS	7
3	GND	5
4	TxD	3
5	RxD	2
6	DCD	1
7	CTS	8
8	DTR	4

Use L-Com TDC005-1 for cabling, 1/16" heat-shrink tubing as required.



Original Date: Wednesday, March 05, 2008	Woods Hole Oceanographic Institution Submersible Engineering & Operations Group
Draft: L. J. Abrams	N456 Navigation System Control Computer
Apvd <Checker>	
Sheet Size: B	
Scale: -	Dwg # - Rev C Sheet 3 of 4



HW1
Fuse Holder
Bussmann
BK/HTB-22I-R

HW2
Fuse Holder
Bussmann
BK/HTB-22I-R

HW1, HW2 each require 2ea 0.187" quick connect terminal.

HW3
Enclosure Handle
Bud
H-9168

HW4
Enclosure Handle
Bud
H-9168

PCB1
WHOI
Ranger Power PCB
4.90" x 2.90"

Original Date: Wednesday, March 05, 2008	Woods Hole Oceanographic Institution Submersible Engineering & Operations Group
Draft: L. J. Abrams	N456 Navigation System Power Supplies
Apvd <Checker>	
Sheet Size: B	
Scale: -	Dwg # - Rev C Sheet 4 of 4

N456 Navigation System
Bill Of Materials - Rev C

Item	Qty	Reference	Part		
1	2	F1,F2		4A Slow	
2	2	HW1,HW2	Bussmann	BK/HTB-22I-R	Fuse Holder
2	2	HW5,HW6	L-Com	TDC005-1	
2	1	HW7	L-Com	TRD695GR-1	
3	1	J1	Amp	206036-1	
4	1	J2	Amp	206061-1	
5	3	J3,J4,J5	L-Com	BA-039	
		Alt	Amphenol	112444	
6	1	J6	L-Com	ECF504-SC5E	
		Alt	L-Com	ECF504-SC6	
7	2	P21,P22		DB9P	
8	2	J21,J22		DB9S	
9	1	J13	Corcom	5EHM1S	
10	1	L3	Bourns	2108	
		Alt	Bourns	2100LL-390	
11	1	PCB1	WHOI	Ranger Power PCB	4.90"2.90"
12	1	PCB2	WHOI	Capacitor Board	3.20"x2.15"
13	2	PCB3,PCB4	WHOI	Magnetics Board	3.20"x2.23"
14	1	PS1	Astrodyne	RS100-24	
15	2	U1,U5	Hydroid	Digital Transponder Board	
16	1	U4	Hydroid	Modem Interface	
17	1	U6	Moxa	NPort 5210	

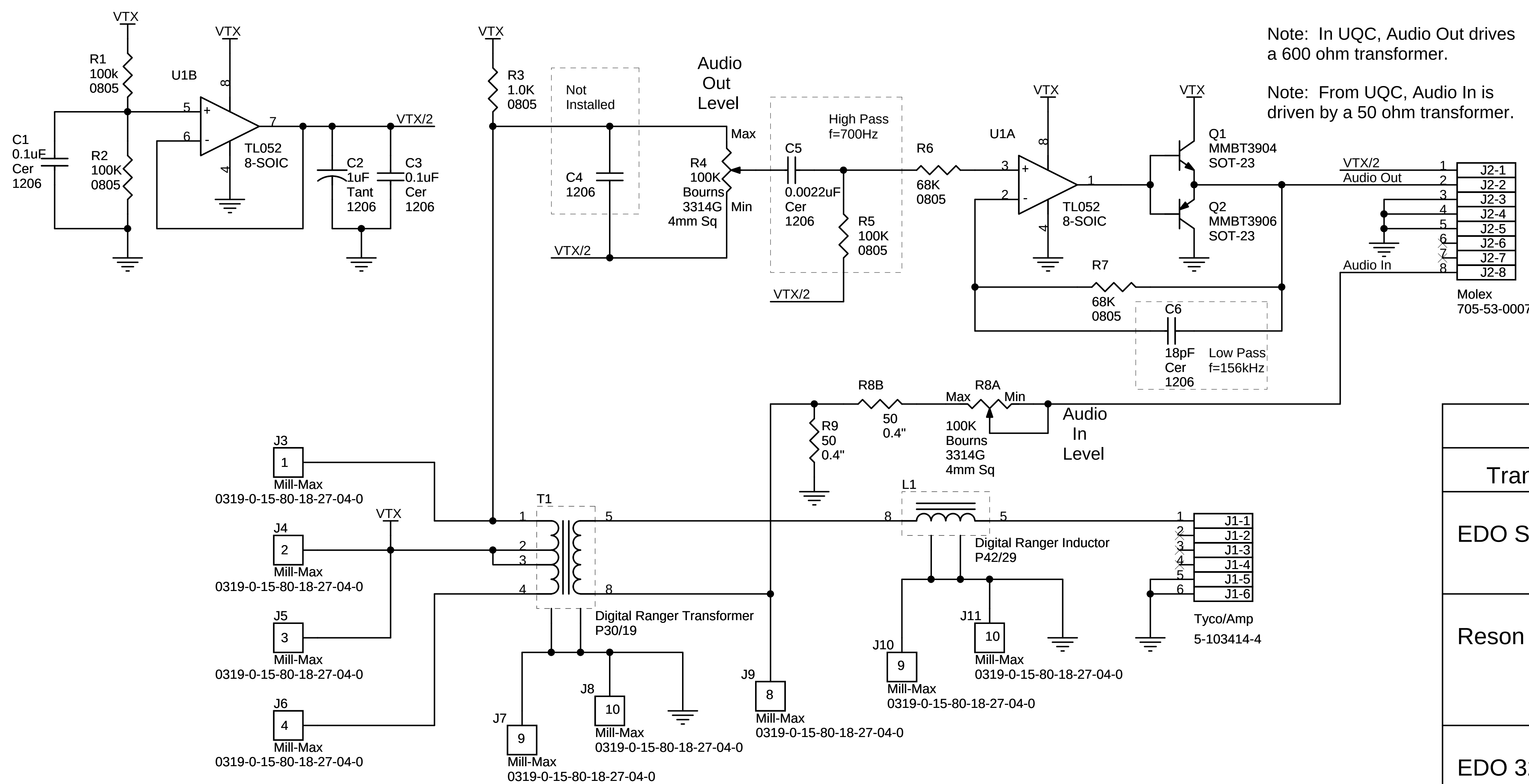
Enclosure Components

1	1	Front Panel	18.9"x3.47"		
2	1	Back Panel	16.4"x3.31"		
3	1	Top Panel	15.9"x12.0"		
4	1	Bottom Panel	15.9"x12.0"		
5	4	Side Profile	Front Panel Express	GLGP1011	305mm
6	7	Housing Bracket	Front Panel Express	GGWS011x	
7	2	Handle	Bud H-9168		

REV	ECA #	REVISION	INIT & DATE	APVD
A		Repair UQC powering	lja	
B		Add AC couple to R4	lja 11Jun2008	
C		Add R8A and shield pins on J2	lja 23Jun2008	

Note: In UQC, Audio Out drives a 600 ohm transformer.

Note: From UQC, Audio In is driven by a 50 ohm transformer.



	Turns, Wire Gauge and Inductance	
Transducer	T1	L1
EDO SP-23-LT	20 bifilar turns of #24 primary 120 turns of #28 secondary Secondary 14.5mH +/-2mH	None Required Install Jumper
Reson TC1037	20 bifilar turns of #24 primary 270 turns of #30 secondary Secondary 73mH +/-5mH Hydroid Drawing SCH-104400	273 turns of #28 12 mH +/- 1.0 Hydroid Drawing 101631-2
EDO 323B	xxx turns of #xx primary xxx turns of #xx secondary	xxx turns of #xx xxx uH
Massa TR-55	xxx turns of #xx primary xxx turns of #xx secondary	xxx turns of #xx xxx uH
ITC 3013 Edgetech 8012 Benthos	20 bifilar turns of #24 primary 270 turns of #30 secondary Secondary 73mH +/-5mH Hydroid Drawing SCH-104400	316 turns of #28 16 mH +/-1.0 Hydroid Drawing 101631-1

Note:
For Line-in/Line-out interface, populate J2 and both op-amp circuits, and omit T1, L1 and J1.

This requires at least Rev 4 PWB.

Note:
For transducer interface, populate T1, L1 and J1 with components appropriate for specific transducer, and omit J2 and all components related to the op-amp circuits.

This requires at least Rev 1 PWB.

Note:
Mating Component for J3-J6, J9 is Mill-Max #3102-2-00-15-00-00-08-0

Note:
Mating Component for J7-J8, J10-J11 is Mill-Max #3145-2-00-15-00-00-08-0

T1 Components:

- HW1 Ferrite Core Ferroxcube P30/19-3B7-A1000
- HW2 Container Ferroxcube CON-P30/19
- HW3 Bobbin Ferroxcube CP-P30/19-1S-C
- HW4 Tag Plate Ferroxcube TGP-P30/19-9P
- HW5 Spring Ferroxcube SPR-P30/19

L1 Components:

- HW6 Ferrite Core Ferroxcube P42/29-3C85-E160
- HW7 Container Ferroxcube CON-P42/29
- HW10 Bobbin Ferroxcube CP-P42/29-1S-C
- HW8 Tag Plate Ferroxcube TGP-P42/29-9P
- HW9 Spring Ferroxcube SPR-P42/29

PCB1 WHOI Magnetics Board 3.20"x2.23"

Original Date: Wednesday, February 06, 2008	Woods Hole Oceanographic Institution Submersible Engineering & Operations Group
Draft: L. J. Abrams	N456 Navigator System Magnetics Daughter Board
Apvd <Checker>	
Sheet Size: B	
Scale: -	*Dwg #* - *Rev* C Sheet 1 of 1

N456 Navigator System
Magnetics Board - Rev C
Bill Of Materials

Item	Qty	Ref	Footprint	Part	
1	2	C1,C3	1206	0.1uF	Cer, 50V
2	1	C2	1206	1uF	Tant, 35V
3	1	C4	1206		
4	1	C5	1206	0.0022uF	Cer, 50V
5	1	C6	1206	18pF	Cer, 50V
6	1	J1	6@0.1"	5-103414-4	
7	1	J2	8@0.1"	705-43-0007	
8	9	J3,J4,J5,J6,J7, J8,J9,J10,J11		0319-0-15-80-18-27-04-0	
9	1	L1	P42/29	Digital Ranger Inductor	
10	1	Q1	SOT-23	MMBT3904	
11	1	Q2	SOT-23	MMBT3906	
12	3	R1,R2,R5	0805	100K	
13	1	R3	0805	1.0K	
14	2	R4,R8A	4mm Sq	100K	Bourns 3314G
15	2	R6,R7	0805	68K	
16	2	R8B,R9	0.4"	50	
17	1	T1	P30/19	Digital Ranger Transformer	
18	1	U1	8-SOIC	TL052	

Other Components

	1	PCB1	3.20"x2.23"	WHOI	Magnetics Board

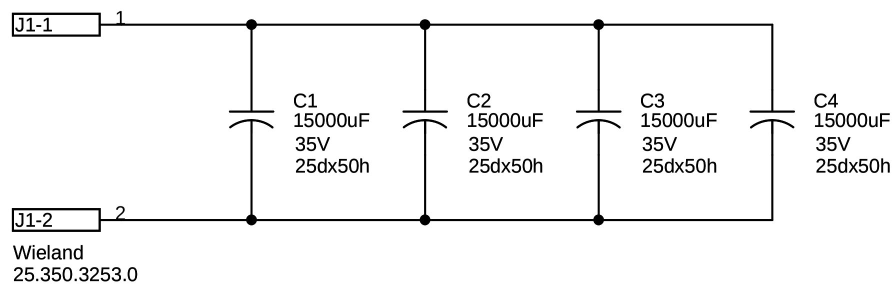
Components for L1 Inductor

1	1	P42/29-3C85-E160	Ferroxcube	Ferrite Core
2	1	CON-P42/29	Ferroxcube	Container
3	1	CP-P42/29-1S-C	Ferroxcube	Bobbin
4	1	TGP-P42/29-9P	Ferroxcube	Tag Plate
5	1	SPR-P42/29	Ferroxcube	Spring

Components for T1 Transformer

1	1	P30/19-3C85-E160	Ferroxcube	Ferrite Core
2	1	CON-P30/19	Ferroxcube	Container
3	1	CP-P30/19-1S-C	Ferroxcube	Bobbin
4	1	TGP-P30/19-9P	Ferroxcube	Tag Plate
5	1	SPR-P30/19	Ferroxcube	Spring

REV	ECA #	REVISION	INIT & DATE	APVD



Alternate for J1:
On Shore Technology
EDSTLZ955/2

Suggested Component for C1-C4:
(30mm max dia, 10mm lead spacing)
United Chemi-Con SMH series
Cornell-Dubilier 381LX series

PCB1
WHOI
Capacitor Board
3.20"x2.15"

Original Date: Wednesday, March 12, 2008

Draft: L. J. Abrams

Apvd <Checker>

Sheet Size: A

Scale: -

Woods Hole Oceanographic Institution
Submersible Engineering & Operations Group

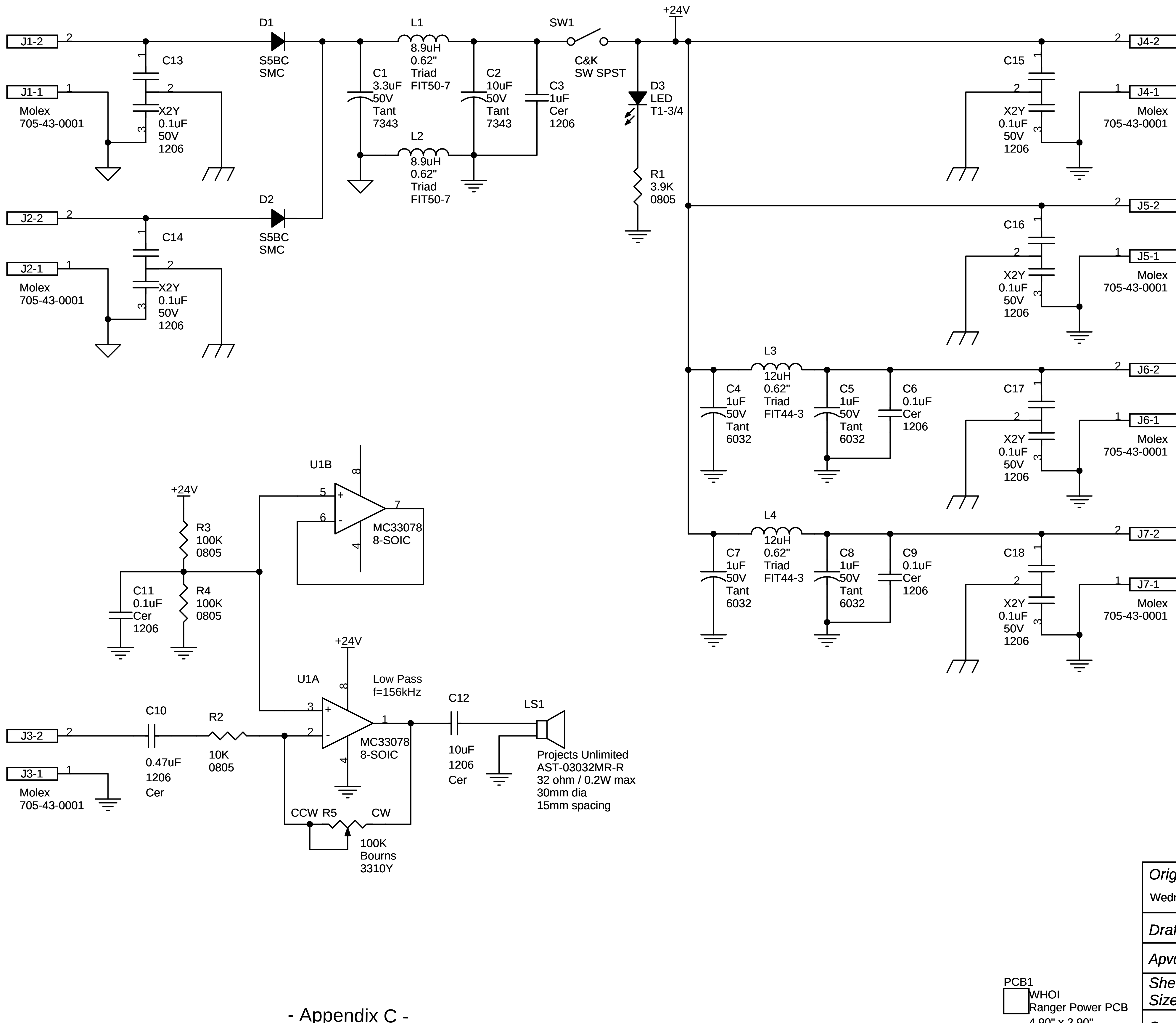
N456 Navigator System
LF Capacitor Board

Dwg # - *Rev* - Sheet 1 of 1

N456 Navigator System
LF Capacitor Board
Bill Of Materials

Item	Qty	Ref	Footprint	Part		
1	4	C1,C2,C3,C4	25dx50h	15000uF	United Chemi-Con	ESMH350VSN153MQ50S
		Alt	30dx40h	15000uF	United Chemi-Con	ESMH350VSN153MR40S
2	1	J1		Wieland	25.350.3253.0	
		Alt		On Shore	EDSTLZ955/2	
3	1	PCB1	3.20"x2.15"	WHOI	Capacitor Board	

REV	ECA #	REVISION	INIT & DATE	APVD
A		Update X2Y Caps	lja 6Aug2008	



Original Date: Wednesday, March 12, 2008	Woods Hole Oceanographic Institution Submersible Engineering & Operations Group
Draft: L. J. Abrams	N456 Navigator System Power Supply Board
Apvd <Checker>	
Sheet Size: B	
Scale: -	*Dwg #* - *Rev* A Sheet 1 of 1

N456 Navigator System
Power Supply Board - Rev A
Bill Of Materials

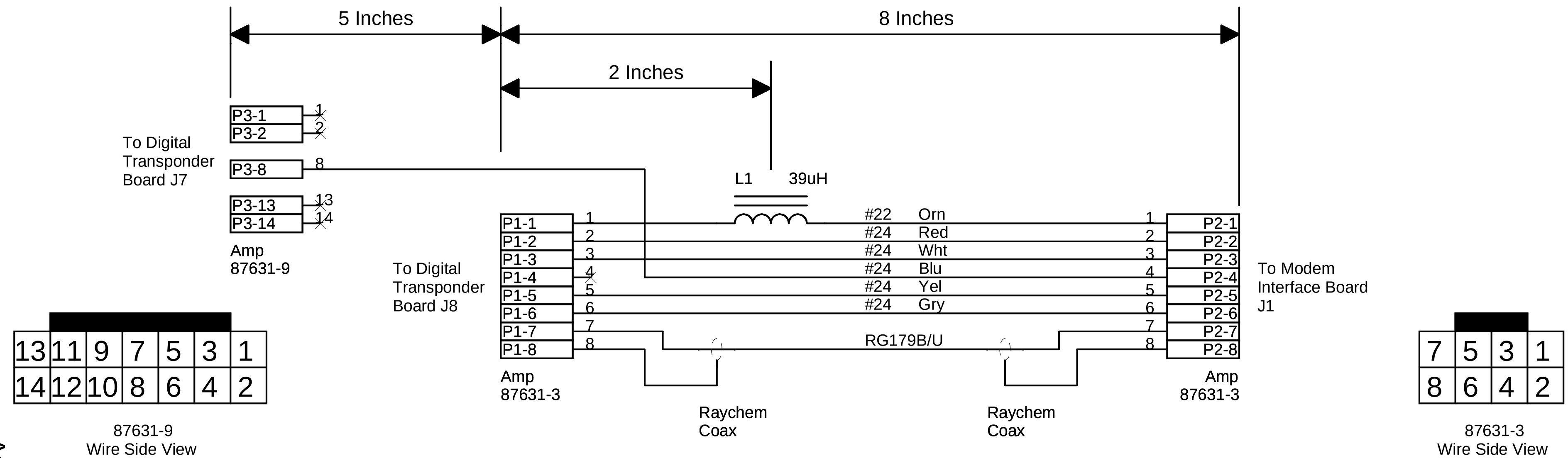
Item	Qty	Ref	Footprint	Part	
1	1	C1	7343	3.3uF	Tant, 50V
2	1	C2	7343	10uF	Tant, 50V
3	1	C3	1206	1uF	Cer, 50V
4	4	C4,C5,C7,C8	6032	1uF	Tant, 50V
5	3	C6,C9,C11	1206	0.1uF	Cer, 50V
6	6	C13,C14,C15, C16,C17,C18	1206	0.1uF	Cer, 50V, CX1206MKX7R9BB104
7	1	C10	1206	0.47uF	Cer, 50V
8	1	C12	1206	10uF	Cer, 25V
9	2	D1,D2	SMC	S5BC	
10	1	D3	T1-3/4	Red	
11	7	J1,J2,J3,J4,J5, J6,J7	2@0.1"	705-43-0001	
12	1	LS1	2@15mm	AST-03032MR-R	
13	2	L1,L2	0.30"	8.9uH	Triad FIT50-7
14	2	L3,L4	0.25"	12uH	Triad FIT44-3
15	1	R1	0805	3.9K	
16	1	R2	0805	10K	
17	2	R3,R4	0805	100K	
18	1	R5		100K	Bourns 3310Y
19	1	SW1		SW SPST	C&K 7101SD9V3Q
20	1	U1	8-SOIC	MC33078	

Other Items

Item	Qty	Ref		Part	
	1	PCB1	4.90" x 2.90"	WHOI	Ranger Power PCB
	1				Knob for R5
	2				Spacer for D3
	4	Spacer	#4-40x0.5"		
	4	Flat Washer	#4		
	4	Lock Washer	#4		
	4	Pan Head	#4-40x3/8"		
	4	Flat Head	#4-40x3/8"		

Note:
D3, LST1, R5, SW1 are mounted on the wiring side

REV	ECA #	REVISION	INIT & DATE	APVD



Notes:

1. All wire to be MIL-W-16878E Type E, Teflon, unless otherwise specified.

2. All crimp terminals to be installed with vendor recommended tooling.

3. Sleeve solder joints to inductor L1 with shrink tubing. Be sure to cover all exposed tinned leads, then cover entire inductor with shrink tubing.

4. Shrink sleeve shield terminations to be installed per Raychem installation guidelines (H54682). Orient ternination with lead wire facing outboard in same direction as inner wires. Trim inner wires and drain lead to 0.75 inch on each end.

5. All cable ends to have location designator labels.

6. Wire tie wire bundle at both sides of inductor.

Original Date: Wednesday, June 11, 2008	Woods Hole Oceanographic Institution Submersible Engineering & Operations Group
Draft: L. J. Abrams	N456 Navigator System Modem Interface Cable to Digital Transponder Board Based on Hydroid SCH-150197 All other notes from SCH-150197 apply.
Apvd <Checker>	
Sheet Size: A	
Scale: -	*Dwg #* - *Rev* - Sheet 1 of 1

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Example Operating Modes

Below are descriptions of the *dsnav* operating modes, as defined in the current Digital Transponder Board firmware, *dsnav* code and *dsnav.ini* file. These modes have been used to track the submarine and elevators.

Ping Types

Pings make a sound at a frequency and start the timer. Their timing is software controlled, so they occur during the requested second.

Dummy pings start the timer but do not make sound.

Untimed pings make a sound but do not start or clear the timer.

Synchronous pings are made coincident with the 1PPS input signal, so they occur exactly on the change from one second to the next.

Frequency Selection

There are 17 transmit ping frequencies. They can be on any frequency in 500 Hz steps between 7.0 kHz and 16.0 kHz (inclusive) with the exception of 12.5 kHz and 15.5 kHz. In addition, a dummy ping can be used in place of a frequency.

There are 16 receive frequencies. They can be on any frequency in 500 Hz steps between 7.0 kHz and 15.0 kHz (inclusive) with the exception of 12.5 kHz.

Only the receive channels on 7.0 kHz and 7.5 kHz can be set as a transponder. They can be independently set to transpond on any available transmit frequency, or to not transpond at all.

Command Mode

In **Command Mode**, *dsnav* initiates pings at the frequency requested, either singly or repeated at the desired rate. It can record the time from the ping to receipt of each receive frequency channel. When repeated, they occur at a controlled interval but not at a controlled time.

Elevator Mode

An elevator acts as a relay transponder, responding on 9.0 kHz when interrogated at 7.0 kHz or 7.5 kHz. The **Elevator Mode** initiates pings at 7.0 kHz or 7.5 kHz on second number 0, 20 and 40, and reports direct travel time to the elevator (on 7.0 kHz or 7.5 kHz) and relay travel times to the transponders (on other frequencies).

Relay Mode – Ship

The ship interrogates the submarine as a relay. The **Relay Mode – Ship** pings on 7.5 kHz at second number 3, 23 and 43, and reports round-trip travel time to the submarine (on 9.0 kHz) and relay travel times to the transponders (on other frequencies).

Relay Mode – Alvin

In **Relay Mode – Alvin**, the submarine responds to interrogations from the ship on 7.5 kHz by pinging on 9.0 kHz. This is done with the transponder function on the 7.5 kHz receive channel.

It makes a dummy ping at second number 2, 22 and 42. When 7.5 kHz is received, its time is recorded for later use. As transponder responses are received, the 7.5 kHz time is subtracted from them to calculate the round-trip travel times to the transponders.

The submarine also makes an untimed ping on 12.0 kHz at second number 58, 1, 18, 21, 38 and 41.

Synchronous Mode – Ship

The ship expects the submarine to make its own transponder net interrogations synchronous to GPS time. In **Synchronous Mode – Ship**, the ship makes a synchronous dummy ping at second number 0, 20 and 40, and reports one-way travel time to the submarine (on 9.0 kHz) and travel times to the transponders (on other frequencies).

Synchronous Mode – Alvin

The submarine interrogates the transponder net on its own, with pings made synchronously with GPS time. In **Synchronous Mode – Alvin**, the submarine makes a synchronous ping on 9.0 kHz at second number 0, 20 and 40, and receives round-trip travel times to the transponders.

It also makes an untimed ping on 12.0 kHz at second number 56, 59, 16, 19, 36 and 39.

```
# N456 INI File
# Nov 22, 2008
# For use in TopLab and in Alvin
#

[GENERAL]
READ_FROM_INI=1
LOGGING=1
NETWORK_LOGGING=0
DATA_DIRECTORY=C:\dsgdata

SIMULATING=0
N_OF_BOARDS=1

INCOMING_SOCKET=10505
SHIP_IN_SOCKET=6002
GPS_IN_SOCKET=55010
CURRENT_MODE=1
DATA_DIRECTORY=C:\

BENTHOS455_IP_ADDRESS=199.92.162.25
BENTHOS455_SOCKET=5001
INCOMING_BENTHOS455_SOCKET=7001

#BENTHOS455_IP_ADDRESS=198.17.154.188
#BENTHOS455_SOCKET=4001
#INCOMING_BENTHOS455_SOCKET=7001

LOGGING_IP_ADDRESS=198.17.154.201
LOGGING_SOCKET=10508
INCOMING_LOGGING_SOCKET=10508

COMPUTATION_SERVER_ADDRESS=198.17.154.139
COMPUTATION_SERVER_SOCKET=55170
INCOMING_COMPUTATION_SERVER_SOCKET=10509

COMPUTATION_SERVER2_ADDRESS=198.17.154.139
COMPUTATION_SERVER2_SOCKET=55171
INCOMING_COMPUTATION_SERVER2_SOCKET=10587

DVLNAV_ADDRESS=199.92.162.25
DVLNAV_SOCKET=55001
INCOMING_DVLNAV_SOCKET=50808

LATITUDE_ORIGIN=9.00
LONGITUDE_ORIGIN=-104.333333333

MAINX=50
MAINY=30


[SHIP]
# Transducer Offsets:
# Positive meters toward bow from mid-ships
# Positive meters toward stbd from centerline
# Positive meters above the keel
##### Or is it relative to the GPS receiver?
TRANSDUCER_ALONGSHIP_OFFSET=5.5
TRANSDUCER_ATHWARTSHIP_OFFSET=-11.0
TRANSDUCER_DEPTH=-5.5

[RELEASE_COMMANDS]
COMMAND_BOARD=1
ENABLED=1
BENTHOS_CODE_1_NAME=9.0A
BENTHOS_CODE_1_FILE=C:\command9.0A.txt
BENTHOS_CODE_2_NAME=9.0B
BENTHOS_CODE_2_FILE=C:\command9.0B.txt

# Principle operating modes
# These modes define the mode selector buttons
# Some of these modes describe the ping cycle directly,
# others point to a CYCLE definition
#
# MODE_NAME = the text name assigned to the mode button
# MODE_TYPE = 0 to produce GUI-defined pings with frequency and interval - No MODE_CYCLE is used, PING_BOARD is
required
#             1 to produce pings as defined in a MODE_CYCLE - MODE_CYCLE is required, PING_BOARD is not
# PING_BOARD = the Digital Transponder Board number.  In general:
```

```
#              Alvin operations always use PING_BOARD=1
#              Jason uses PING_BOARD=1
#              Medea uses PING_BOARD=2
# MODE_CYCLE = the name of a ping cycle definition
# IS_TIMED = 0 if pings occur at the commanded instant
#            1 if pings occur on even second mark
# MODE_STRING = the data type provided to DVLNAV in the $WHTT sentence.
# IS_TRANSPONDER = 1 if there is a transpond channel
#                    The travel time from the TRANSPOND_IN_CHANNEL is subtracted from the other travel times.
#                  0 if there are no transpond channels
# TRANSPOND_IN_CHANNEL = the receive channel number which triggers transponding.
# TRANSPOND_OUT_CHANNEL = the channel number produced upojn transponding.

[MODE_1]
# Produce pings described manually by frequency and interval
MODE_NAME=Command
MODE_TYPE=0
PING_BOARD=1
MODE_STRING=RSA

# [MODE_2]
# MODE_NAME="PRV Mode"
# MODE_TYPE=0
# PING_BOARD=2
# LISTEN_BOARD=3
# IS_PRV=1

[MODE_3]
# Ping an elevator 11.0 every 20 seconds, it then interrogates the net on 9.0
# Listen for travel times from the elevator on 9.0 and the transponders.
MODE_NAME="Elevator Cycle - 11.0"
MODE_TYPE=1
IS_TIMED=1
MODE_CYCLE=ELEVATOR_CYCLE_110

[MODE_4]
# Ping an elevator on 11.5 every 20 seconds, it then interrogates the net on 9.0
# Listen for travel times from the elevator on 9.0 and the transponders.
MODE_NAME="Elevator Cycle - 11.5"
MODE_TYPE=1
IS_TIMED=1
MODE_CYCLE=ELEVATOR_CYCLE_115

[MODE_5]
# Ping the Alvin on 7.5 every 20 seconds, the submarine then interrogates the net on 9.0
# Listen for travel times from the submarine on 9.0 and the transponders.
MODE_NAME="Relay Nav - Ship"
MODE_TYPE=1
IS_TIMED=1
MODE_CYCLE=RELAY_NAV_CYCLE

[MODE_6]
# Expect to be interrogated on 7.5 every 20 seconds; transpond on 9.0
# Use a dummy ping 1 second earlier to time the 7.5 as well as the transponder returns.
# The time of the 7.5 is then subtracted from the transponder recept times
# Also make tracking pings every 3 seconds on 12.0
# Tracking pulses are clearing the travel time timer, so don't issue very many of them
MODE_NAME="Relay Nav - Alvin"
IS_TRANSPONDER=1
TRANSPOND_IN_CHANNEL=1
TRANSPOND_OUT_CHANNEL=5
MODE_TYPE=1
IS_TIMED=1
MODE_CYCLE=RELAY_ALVIN_CYCLE_HACK

[MODE_7]
# Expect the Alvin to make synchronous interrogation pings every 20 seconds on 9.0
# Use a dummy ping at the same instant to time submarine slant range and transponder returns.
MODE_NAME="Synchronous Nav - Ship"
MODE_TYPE=1
MODE_CYCLE=SHIP_SYNC_CYCLE
IS_TIMED=1

[MODE_8]
# Alvin makes synchronous interrogation pings every 20 seconds on 9.0
# Also make tracking pings every 3 seconds on 12.0
# Tracking pulses are clearing the travel time timer, so don't issue very many of them
MODE_NAME="Synchronous Nav - Alvin"
MODE_TYPE=1
```

```
MODE_CYCLE=SUB_SYNC_CYCLE_HACK
IS_TIMED=1

[MODE_9]
# Make tracking pings every 3 seconds on 12.0
MODE_NAME="Synchronous Nav - Tracking Only"
MODE_TYPE=1
MODE_CYCLE=SUB_SYNC_CYCLE_TRACK_ONLY
IS_TIMED=1


# Ping Cycle Desfinitions
# Each named cycle defines one minute of pings
# For each ping:
# PING_x = the number of the second on which the ping should occur (0 - 59)
# PING_x_TYPE = 0 to reset the travel time timer when the ping occurs
#                1 do not reset the travel time timer
# PING_x_CHANNEL = the output channel number
# PING_x_BOARD = the Digital Transponder Board making the ping.
# PING_x_SOURCE = 0 the ping is produced synchronously on the 1PPS signal
#                  1 the ping is produced when the command is issued
# PING_x_MODE_STRING = the data type provided to DVLNAV in the $WHTT sentence.

[ELEVATOR_CYCLE_110]
# Channel 9 is 11.0 kHz
PING_1=0
PING_1_TYPE=0
PING_1_CHANNEL=9
PING_1_BOARD=1
PING_1_SOURCE=1
PING_1_MODE_STRING=RSA

PING_2=20
PING_2_TYPE=0
PING_2_CHANNEL=9
PING_2_BOARD=1
PING_2_SOURCE=1
PING_2_MODE_STRING=RSA

PING_3=40
PING_3_TYPE=0
PING_3_CHANNEL=9
PING_3_BOARD=1
PING_3_SOURCE=1
PING_3_MODE_STRING=RSA


[ELEVATOR_CYCLE_115]
# Channel 10 is 11.5 kHz
PING_1=0
PING_1_TYPE=0
PING_1_CHANNEL=10
PING_1_BOARD=1
PING_1_SOURCE=1
PING_1_MODE_STRING=RSA

PING_12=20
PING_2_TYPE=0
PING_2_CHANNEL=10
PING_2_BOARD=1
PING_2_SOURCE=1
PING_2_MODE_STRING=RSA

PING_3=40
PING_3_TYPE=0
PING_3_CHANNEL=10
PING_3_BOARD=1
PING_3_SOURCE=1
PING_3_MODE_STRING=RSA


[RELAY_NAV_CYCLE]
# Channel 2 is 7.5 kHz
PING_1=3
PING_1_TYPE=0
PING_1_CHANNEL=2
PING_1_BOARD=1
PING_1_SOURCE=1
PING_1_MODE_STRING=RSA
```

```
PING_2=23
PING_2_TYPE=0
PING_2_CHANNEL=2
PING_2_BOARD=1
PING_2_SOURCE=1
PING_2_MODE_STRING=RSA

PING_3=43
PING_3_TYPE=0
PING_3_CHANNEL=2
PING_3_BOARD=1
PING_3_SOURCE=1
PING_3_MODE_STRING=RSA


[RELAY_ALVIN_CYCLE_HACK]
# Channel 11 is 12.0 kHz
# Channel 18 is a dummy ping
PING_1=1
PING_1_TYPE=1
PING_1_CHANNEL=11
PING_1_BOARD=1
PING_1_SOURCE=0

PING_2=2
PING_2_TYPE=0
PING_2_CHANNEL=18
PING_2_BOARD=1
PING_2_SOURCE=0
PING_2_MODE_STRING=RAA

PING_3=15
PING_3_TYPE=1
PING_3_CHANNEL=11
PING_3_BOARD=1
PING_3_SOURCE=0

PING_4=18
PING_4_TYPE=1
PING_4_CHANNEL=11
PING_4_BOARD=1
PING_4_SOURCE=0

PING_5=21
PING_5_TYPE=1
PING_5_CHANNEL=11
PING_5_BOARD=1
PING_5_SOURCE=0

PING_6=22
PING_6_TYPE=0
PING_6_CHANNEL=18
PING_6_BOARD=1
PING_6_SOURCE=0
PING_6_MODE_STRING=RAA

PING_7=35
PING_7_TYPE=1
PING_7_CHANNEL=11
PING_7_BOARD=1
PING_7_SOURCE=0

PING_8=38
PING_8_TYPE=1
PING_8_CHANNEL=11
PING_8_BOARD=1
PING_8_SOURCE=0

PING_9=41
PING_9_TYPE=1
PING_9_CHANNEL=11
PING_9_BOARD=1
PING_9_SOURCE=0

PING_10=42
PING_10_TYPE=0
PING_10_CHANNEL=18
PING_10_BOARD=1
```

```
PING_10_SOURCE=0
PING_10_MODE_STRING=RAA

PING_11=55
PING_11_TYPE=1
PING_11_CHANNEL=11
PING_11_BOARD=1
PING_11_SOURCE=0

PING_12=58
PING_12_TYPE=1
PING_12_CHANNEL=11
PING_12_BOARD=1
PING_12_SOURCE=0


[SHIP_SYNC_CYCLE]
# Channel 18 is a dummy ping
PING_1=0
PING_1_TYPE=0
PING_1_CHANNEL=18
PING_1_BOARD=1
PING_1_SOURCE=0
PING_1_MODE_STRING=DAA

PING_2=20
PING_2_TYPE=0
PING_2_CHANNEL=18
PING_2_BOARD=1
PING_2_SOURCE=0
PING_2_MODE_STRING=DAA

PING_3=40
PING_3_TYPE=0
PING_3_CHANNEL=18
PING_3_BOARD=1
PING_3_SOURCE=0
PING_3_MODE_STRING=DAA


[SUB_SYNC_CYCLE_HACK]
# Channel 5 is 9.0 kHz
# Channel 11 is 12.0 kHz
PING_1=0
PING_1_TYPE=0
PING_1_CHANNEL=5
PING_1_BOARD=1
PING_1_SOURCE=0
PING_1_MODE_STRING=RSA

PING_2=13
PING_5_TYPE=1
PING_2_CHANNEL=11
PING_2_BOARD=1
PING_2_SOURCE=0

PING_3=16
PING_3_TYPE=1
PING_3_CHANNEL=11
PING_3_BOARD=1
PING_3_SOURCE=0

PING_4=19
PING_4_TYPE=1
PING_4_CHANNEL=11
PING_4_BOARD=1
PING_4_SOURCE=0

PING_5=20
PING_5_TYPE=0
PING_5_CHANNEL=5
PING_5_BOARD=1
PING_5_SOURCE=0
PING_5_MODE_STRING=RSA

PING_6=33
PING_6_TYPE=1
PING_6_CHANNEL=11
PING_6_BOARD=1
```

```
PING_6_SOURCE=0

PING_7=36
PING_7_TYPE=1
PING_7_CHANNEL=11
PING_7_BOARD=1
PING_7_SOURCE=0

PING_8=39
PING_8_TYPE=1
PING_8_CHANNEL=11
PING_8_BOARD=1
PING_8_SOURCE=0

PING_9=40
PING_9_TYPE=0
PING_9_CHANNEL=5
PING_9_BOARD=1
PING_9_SOURCE=0
PING_9_MODE_STRING=RSA

PING_10=53
PING_10_TYPE=1
PING_10_CHANNEL=11
PING_10_BOARD=1
PING_10_SOURCE=0

PING_11=56
PING_11_TYPE=1
PING_11_CHANNEL=11
PING_11_BOARD=1
PING_11_SOURCE=0

PING_12=59
PING_12_TYPE=1
PING_12_CHANNEL=11
PING_12_BOARD=1
PING_12_SOURCE=0

[SUB_SYNC_CYCLE_TRACK_ONLY]
# Channel 11 is 12.0 kHz
PING_1=0
PING_1_TYPE=1
PING_1_CHANNEL=11
PING_1_BOARD=1
PING_1_SOURCE=0

PING_2=3
PING_2_TYPE=1
PING_2_CHANNEL=11
PING_2_BOARD=1
PING_2_SOURCE=0

PING_3=6
PING_3_TYPE=1
PING_3_CHANNEL=11
PING_3_BOARD=1
PING_3_SOURCE=0

PING_4=9
PING_4_TYPE=1
PING_4_CHANNEL=11
PING_4_BOARD=1
PING_4_SOURCE=0

PING_5=12
PING_5_TYPE=1
PING_5_CHANNEL=11
PING_5_BOARD=1
PING_5_SOURCE=0

PING_6=15
PING_6_TYPE=1
PING_6_CHANNEL=11
PING_6_BOARD=1
PING_6_SOURCE=0

PING_7=18
PING_7_TYPE=1
```

```
PING_7_CHANNEL=11
PING_7_BOARD=1
PING_7_SOURCE=0

PING_8=21
PING_8_TYPE=1
PING_8_CHANNEL=11
PING_8_BOARD=1
PING_8_SOURCE=0

PING_9=24
PING_9_TYPE=1
PING_9_CHANNEL=11
PING_9_BOARD=1
PING_9_SOURCE=0

PING_10=27
PING_10_TYPE=1
PING_10_CHANNEL=11
PING_10_BOARD=1
PING_10_SOURCE=0

PING_11=30
PING_11_TYPE=1
PING_11_CHANNEL=11
PING_11_BOARD=1
PING_11_SOURCE=0

PING_12=33
PING_12_TYPE=1
PING_12_CHANNEL=11
PING_12_BOARD=1
PING_12_SOURCE=0

PING_13=36
PING_13_TYPE=1
PING_13_CHANNEL=11
PING_13_BOARD=1
PING_13_SOURCE=0

PING_14=39
PING_14_TYPE=1
PING_14_CHANNEL=11
PING_14_BOARD=1
PING_14_SOURCE=0

PING_15=42
PING_15_TYPE=1
PING_15_CHANNEL=11
PING_15_BOARD=1
PING_15_SOURCE=0

PING_16=45
PING_16_TYPE=1
PING_16_CHANNEL=11
PING_16_BOARD=1
PING_16_SOURCE=0

PING_27=48
PING_27_TYPE=1
PING_27_CHANNEL=11
PING_27_BOARD=1
PING_27_SOURCE=0

PING_28=51
PING_28_TYPE=1
PING_28_CHANNEL=11
PING_28_BOARD=1
PING_28_SOURCE=0

PING_29=54
PING_29_TYPE=1
PING_29_CHANNEL=11
PING_29_BOARD=1
PING_29_SOURCE=0

PING_30=57
PING_30_TYPE=1
PING_30_CHANNEL=11
```

```
PING_30_BOARD=1
PING_30_SOURCE=0


[BOARD_1]
#BOARD_IP_ADDRESS=199.92.162.40
#BOARD_IP_ADDRESS=199.92.162.41
BOARD_IP_ADDRESS=199.92.162.42
BOARD_SOCKET=4001
INCOMING_SOCKET=6001

BOARD_TT_OFFSET=0.020  // in seconds, will be added to the measured tt

TTPLOT_X=418
TTPLOT_Y=30
TTPLOT_SHOW=1

TIMEPLOT_X=418
TIMEPLOT_Y=380
TIMEPLOT_WIDTH=700
TIMEPLOT_HEIGHT=600
TIMEPLOT_SHOW=1


N_OF_IN_CHANNELS=16
BOARD_LABEL=Ship

CHANNEL_1=7.0
USE_CHANNEL_1=0
CHANNEL_1_LABEL=G
BENTHOS_LABEL_1=6.5
CHANNEL_1_COLOR=13

CHANNEL_2=7.5
CHANNEL_2_LABEL=F
BENTHOS_LABEL_2=9.0
QUERY_CHANNEL_2=0
USE_CHANNEL_2=0
CHANNEL_2_COLOR=18

CHANNEL_3=8.0
CHANNEL_3_LABEL=G
BENTHOS_LABEL_3=9.5
CHANNEL_3_COLOR=2

CHANNEL_4=8.5
CHANNEL_4_LABEL=D
BENTHOS_LABEL_4=10.0
CHANNEL_4_COLOR=2

CHANNEL_5=9.0
CHANNEL_5_LABEL=1
BENTHOS_LABEL_5=9.0
USE_CHANNEL_5=1
CHANNEL_5_COLOR=7
CHANNEL_5_MINIMUM_TT=0.8
CHANNEL_5_MAXIMUM_TT=5.0
CHANNEL_5_INTERPING_GAP=0.5

CHANNEL_6=9.5
CHANNEL_6_LABEL=Z
bENTHOS_LABEL_6=7.5
USE_CHANNEL_6=0
CHANNEL_6_COLOR=2

CHANNEL_7=10.0
CHANNEL_7_LABEL=B
BENTHOS_LABEL_7=8.5
USE_CHANNEL_7=1
CHANNEL_7_COLOR=8

CHANNEL_8=10.5
CHANNEL_8_LABEL=C
BENTHOS_LABEL_8=9.5
USE_CHANNEL_8=1
CHANNEL_8_COLOR=10

CHANNEL_9=11.0
CHANNEL_9_LABEL=G
```

```
BENTHOS_LABEL_9=6.5
CHANNEL_9_COLOR=9

CHANNEL_10=11.5
CHANNEL_10_LABEL=F
BENTHOS_LABEL_10=9.0
USE_CHANNEL_10=1
CHANNEL_10_COLOR=11

QUERY_CHANNEL_11=0
CHANNEL_11=12.0
CHANNEL_11_LABEL=G
BENTHOS_LABEL_11=9.5
CHANNEL_11_COLOR=2

CHANNEL_12=13.0
CHANNEL_12_LABEL=A
BENTHOS_LABEL_12=8.0
USE_CHANNEL_12=0
CHANNEL_12_COLOR=2

CHANNEL_13=13.5
CHANNEL_13_LABEL=A
BENTHOS_LABEL_13=10.5
USE_CHANNEL_13=0
CHANNEL_13_COLOR=1

CHANNEL_14=14.0
CHANNEL_14_LABEL=Z
bENTHOS_LABEL_14=7.5
CHANNEL_14_COLOR=2

CHANNEL_15=14.5
CHANNEL_15_LABEL=B
BENTHOS_LABEL_15=8.0
CHANNEL_15_COLOR=13

CHANNEL_16=15.0
CHANNEL_16_LABEL=Y
BENTHOS_LABEL_16=8.5
CHANNEL_16_COLOR=17


N_OF_OUT_CHANNELS=18
OUT_CHANNEL_1=7.0
OUT_CHANNEL_2=7.5
OUT_CHANNEL_3=8.0
OUT_CHANNEL_4=8.5
OUT_CHANNEL_5=9.0
OUT_CHANNEL_6=9.5
OUT_CHANNEL_7=10.0
OUT_CHANNEL_8=10.5
OUT_CHANNEL_9=11.0
OUT_CHANNEL_10=11.5
OUT_CHANNEL_11=12.0
OUT_CHANNEL_12=13.0
OUT_CHANNEL_13=13.5
OUT_CHANNEL_14=14.0
OUT_CHANNEL_15=14.5
OUT_CHANNEL_16=15.0
OUT_CHANNEL_17=16.0
OUT_CHANNEL_18=20.0
DEFAULT_CHANNEL=1
```

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REPORT DOCUMENTATION PAGE	1. REPORT NO. **WHOI-2009-01**	2.	3. Recipient's Accession No.
4. Title and Subtitle The N456 Navigator System			5. Report Date January 2009 6.
7. Author(s) Lane J. Abrams			8. Performing Organization Rept. No.
9. Performing Organization Name and Address Woods Hole Oceanographic Institution Woods Hole, Massachusetts 02543			10. Project/Task/Work Unit No. 11. Contract(C) or Grant(G) No. (C) OCE-0514060 (G) OCE-0217076
12. Sponsoring Organization Name and Address National Science Foundation			13. Type of Report & Period Covered Technical Report 14.

15. Supplementary Notes

This report should be cited as: Woods Hole Oceanog. Inst. Tech. Rept., **WHOI-2009-01**.

16. Abstract (Limit: 200 words)

The N456 Navigator has been developed to assist in Long Baseline (LBL) acoustic navigation. Its two basic functions are generation of acoustic signals, and receipt and timing of returns. When combined with the new dsnav software this becomes the basic component of an LBL navigation system. The principal motivation for this development was as a replacement for the Benthos 455 Acoustic Signal Processor and the Alvin's NavBox. The N456 is intended for use in the Jason Control Van, in the Alvin submersible, and in the Atlantis TopLab. Enough flexibility is built into this system to be able to interface with a wide variety of ceramic transducers, or with an EDO 5400 Underwater Telephone.

Through the hardware and software of the system a series of pings is generated, which are used to interrogate underwater vehicles, instruments, or transponder nets. Once pings are generated, transponders or vehicles, hear them and may respond with pings of their own. The basic LBL function is based on timing the receipt of these responses, calculating the distance the transponders or vehicles (by knowing the speed of sound), and calculating the best-fit location.

17. Document Analysis a. Descriptors

Acoustic Navigation
Long Baseline
Benthos 455 ASP

b. Identifiers/Open-Ended Terms

c. COSATI Field/Group

18. Availability Statement	19. Security Class (This Report)	21. No. of Pages
Approved for public release; distribution unlimited.	UNCLASSIFIED	52
	20. Security Class (This Page)	22. Price

(See ANSI-Z39.18) *See Instructions on Reverse* OPTIONAL FORM 272 (4-77)
(Formerly NTIS-35)
Department of Commerce